A046 978

A STUDY OF SHIP ACQUISITION COST ESTIMATING IN THE NAVAL SEA SYSTEMS COMMAND

A REVIEW AND ANALYSIS OF THE COST
ESTIMATING PROCESS AS IT RELATES
TO RECENT COST GROWTH IN SHIP
AND WEAPONS PROCUREMENT IN THE NAVY

APPENDICES

OCTOBER 1977

NAVAL SEA SYSTEM COMMAND
DEPARTMENT OF THE NAVY
WASHINGTON, D.C. 20362

-- 1 OF 3
-- 1 - AD NUMBER: A046978
-- 2 - FIELDS AND GROUPS: 5/3, 13/10, 15/5
-- 5 - CORPORATE AUTHOR: INTERNATIONAL MARITIME ASSOCIATES INC WASHINGTON
-- DC
-- 6 - UNCLASSIFIED TITLE: A STUDY OF SHIP ACQUISITION COST ESTIMATING
-- IN THE NAVAL SEA SYSTEMS COMMAND. APPENDICES.
-- 9 - DESCRIPTIVE NOTE: FINAL REPT.
--11 - REPORT DATE: OCT , 1977
--12 - PAGINATION: 1298P HC COST: $ 88.86
--15 - CONTRACT NUMBER: N00024-77-C-2013
--20 - REPORT CLASSIFICATION: UNCLASSIFIED
--21 - SUPPLEMENTARY NOTE: APPENDICES TO REPORT DATED 28 OCT 77, AD-
-- A046 977. SEE ALSO AD-A046 976.
--33 - LIMITATION CODES: 1

A STUDY OF SHIP ACQUISITION

COST ESTIMATING

IN THE

NAVAL SEA SYSTEMS COMMAND

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Prepared under Contract No. N00024-77-C-2013

for

Naval Sea Systems Command
Department of the Navy
Washington, D.C. 20362

International Maritime Associates, Inc.
Washington, D.C.

APPENDIX A

THE SHIPBUILDING INDUSTRY

Appendix 1 of 5

Supports the final report entitled, A Study Of Ship Acquisition Cost Estimating In The Naval Sea Systems Command

Contract No. N00024-77-C-2013

INTERNATIONAL MARITIME ASSOCIATES, INC.

WASHINGTON, D. C.

OCTOBER 1977

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THE SHIPBUILDING INDUSTRY

This section of the report provides an overview of the shipbuilding industry, placing into perspective the cost problems experienced in naval ship construction. It describes the nature of the industry and its problems, emphasizing:

- The concentration of the industry as reflected by an increasingly limited number of shipbuilders
- The sudden, erratic movement in labor and material cost that has impacted shipbuilders worldwide
- That NAVSEA's inability to accurately estimate costs in the recent environment is shared by shipbuilders in the U.S. and other countries

General background data is also provided for reference purposes in understanding the environment within which NAVSEA must estimate future ship construction costs.

1. SHIPBUILDING IS A HEAVY FABRICATION INDUSTRY PRODUCING SMALL NUMBERS OF EXPENSIVE, COMPLEX UNITS OF OUTPUT

The ship construction industry exhibits many of the characteristics usually associated with the construction of commercial buildings and other land-based facilities of special nature, usually one-of-a-type design. Instability of the market within which construction firms operate has been recognized as a major impediment to technological advances and productivity. Involved are large, complex and expensive projects for only one, or at best a limited number of similar products. The nature of the industry limits use of jigs, fixtures and automatic tools such as employed extensively in production line industries such as automotive products and the airframe industry.

(1) Due To Its Heavy Construction Orientation, Shipbuilding Permits Only Limited Application Of Automation And Mechanization

Shipbuilding is a highly labor intensive industry where manual and supervisory skills are vital. Modern shipyards may be laid out for continuous, but not necessarily straightline steel flow. Continuous sequencing cannot always be maintained, particularly in the building of naval ships. Due to the usual demand for relatively small numbers of ships in any one production group, and the

need to make modifications in successive ships to suit commercial trade or military requirements, it is difficult to justify investment in costly special tools. Also, orders for standard or repetitive ships may be unobtainable in a timely manner to assure continuous shipway production, hence stops and startups are a frequent occurrence. This applies to both commercial and naval ship construction.

It is difficult to increase the capital/labor ratio, particularly in an atmosphere of uncertain yearly ship demand.

However, it should be noted that, in the past few years, U.S. shipyards have invested large amounts of capital in modernizing facilities. And, when ship orders are available, they are able to produce runs of duplicate ships.

(2) Limited Automation And Mechanization Applies To Shipbuilding In All Countries

Even the highly publicized modern shipyards in Japan, Sweden, United States and other countries are unable to extensively use mechanized manufacturing processes for anything other than fabricating steel which ultimately is then assembled is larger modular segments. These modules are invariably regulated and adjusted by hand in the final shipway or construction dock. Machinery and

equipment are usually purchased from non-shipyard sources, thus the shipyard's share of the commercial ship contract is often less than half of the total contract price.

(3) Availability And Cost Of A Stable And Skilled Labor Force Is Affected By Economic Conditions In Both The Shipbuilding And Commercial Construction Industries

Shipyards are continually faced with cyclical lay-offs, while simultaneously undertaking large and costly training programs to assure skilled worker availability at a later period. Attrition in these training programs is very high, especially among welders, steelfitters, electricians, machinists and pipefitters who gravitate to higher paying industries with opportunities for considerable overtime. Also, recent Federal pension regulations permitting transfer of pension funds has reduced interest in service tenure.

Labor force stability is a critical element. Yet, volatility of the shipbuilding and repair labor force resulting from cyclical ship construction contracting and loss of skilled workers to higher paying industries is evidenced by the high monthly labor turnover rates. As shown in Table A.1, turnover is almost double that of the manufacturing industry.

TABLE A.1

LABOR TURNOVER [1]

(Per 100 workers per month)

YEAR	MANUFACTURING	SHIPBUILDING AND REPAIR
1960	8.1	22.6
1965	8.4	18.8
1966	9.6	17.7
1967	9.0	17.5
1968	9.2	17.7
1969	9.6	16.3
1970	8.8	15.4
1971	8.1	17.2
1972	8.6	15.9
1973	9.4	15.4
1974	9.0	13.9
1975	7.9	12.2
1976	7.7	12.5 (thru October)

SOURCE: Bureau of Labor Statistics, Employment and Earnings

(1) Labor turnover is the total of accessions (new hires and rehires) and separations (quits, lay-offs, terminations, deaths, disability and retirement).

The effect of the Merchant Marine Act of 1970 with its increase in ship construction and the large naval programs has been to reduce the shipbuilding and repair labor turnover from 22.6 percent per month in 1960 to an average of about 13 percent in 1975 and 1976. Undoubtedly, some portion of this improved stability results from the higher unemployment during these two years.

(4) <u>Wages For Comparable Skills In U.S. Shipbuilding Are Lower Than In Contract Building Construction, Causing A Drain Of Skilled Workers</u>

Comparative industry wages shown in Table A.2 represent gross average hourly earnings or take-home pay during the period of 1967-1976. This figure includes incentives, overtime and late shift pay, but does not include fringes or irregular bonuses and hence does not represent the full cost of each employee. Average hourly earnings, however, are a reasonable indicator of relative labor costs. During this 1967-1976 period, shipbuilding wages in the U.S. increased 74 percent compared to 89 percent for commercial construction. The wage gap between these two industries -- competing in an overlapping labor market -- remains appreciable. This will have the effect of draining skilled workers from shipbuilding to contract construction.

TABLE A.2

AVERAGE HOURLY EARNINGS IN SELECTED INDUSTRIES 1967-1976

Year	Shipbuilding & Repair	Transportation and Public Utilities	Durable Goods	Manu-facturing	Contract Construction	Total Private
1967	$3.44	$3.24	$3.00	$2.83	$4.11	$2.68
1968	3.58	3.42	3.19	3.01	4.41	2.85
1969	3.81	3.64	3.38	3.19	4.79	3.04
1970	3.96	3.85	3.55	3.36	5.24	3.22
1971	4.12	4.31	3.79	3.57	5.69	3.44
1972	4.36	4.64	4.06	3.81	6.03	3.67
1973	4.61	5.04	4.34	4.08	6.37	3.92
1974	4.98	5.43	4.69	4.41	6.75	4.22
1975	5.51	5.92	5.14	4.81	7.25	4.54
1976	6.01	6.46	5.50	5.19	7.68	4.87
Percent Increase 1967-1976	74	99	83	83	89	82

SOURCE: Bureau of Labor Statistics, Employment and Earnings

It is noted, however, that during the past few years the yearly percentage of increase has been generally greater for shipbuilding than for contract construction. Based on recent trends, it is anticipated that U.S. shipyard wages will by the mid-80's be more nearly equivalent to wages in contract construction.

2. MERCHANT SHIP CONSTRUCTION IS CONCENTRATED IN A HANDFUL OF COUNTRIES

The number of major shipbuilding countries worldwide tends to be relatively few. This reflects the relatively small yearly output of approximately 2000-3000 ships* worldwide, with a much smaller output of major naval ships. Such level of output cannot support many competitors, and as will be described, historical market penetration has resulted in one country dominant in merchant construction.

(1) The Rate Of Growth And Character Of International Trade Drive The Demand For Merchant Shipbuilding

International trade is the stimulant for international shipbuilding. The volume of international trade, measured in dollar value of shipments, has increased at the annual average of 18 percent over the past ten years. Dollar increases during 1973 and 1974 were exceptionally large, caused in part by the higher

* 2000 DWT or more

inflation rates in these years. However, there was a considerable drop in 1975, when a trade increase of only 3.4 percent was indicated which reflected world conditions.

The greatest overall trade growths have been in bulk and liquid cargoes which resulted in the construction of large tankers and bulk carriers in the 1970's. Shift in trade patterns and projections have had significant effects on charter and freight rates and hence volume of new construction orders. Typical is the quadrupling of crude oil prices during the past two years which lowered the importation of fuel oils by the industrial nations, either on an actual or growth rate basis. The tremendous lay-up of tanker tonnage (over ten percent of total world tonnage) and to a lesser extent dry cargo tonnage as shown in Table A.3 and the consequent reduction and cancellations of many VLCC orders have created chaotic conditions among the major world shipbuilders.

Other factors that affect the shipbuilding market, which may be called "step functions," are caused by some new or totally unanticipated occurrences, good, or bad. In addition to the aforementioned oil prices, "step functions" could include growing maritime nationalism, currency devaluations, bilateral shipping

TABLE A.3

WORLD LAID-UP TONNAGE
(000's DWT)

	Dry Cargo	Tanker	Total
Oct. 1974	404	915	1,319
Jan. 1975	459	3,602	4,061
Apr. 1975	2,920	17,189	20,109
July 1975	7,140	29,609	36,749
Oct. 1975	8,250	34,894	43,144
Jan. 1976	8,137	41,422	49,560
Apr. 1976	8,408	44,797	53,204
July 1976	6,809	42,813	49,622
Oct. 1976	4,979	32,867	37,846
Jan. 1977	5,532	30,291	35,823
Apr. 1977	5,967	26,254	32,221

SOURCE: Seatrade

agreements, closing of critical waterways (i.e., Panama and Suez Canals) and new concepts of transportation, among others. Any of these factors can cause significant changes in the market price which can be unrelated to cost.

While the amount of laid-up tonnage is slowly decreasing, it is estimated that the demand for large international tankers will not return until at least 1985, with the present shipbuilding requirements being confined to limited numbers and total tonnages of small tankers, bulk carriers and special type cargo ships. The June 1977 issue of "SEATRADE" states "no light yet at the end of the tanker market tunnel." Many owners are scrapping the smaller, over ten year old ships, in part helped by high steel scrap prices in Taiwan, as a means of reducing unprofitable tonnage.

(2) Eighty Percent Of Merchant Ship Deadweight Tonnage Now On Order Is Concentrated In Nine Countries

As shown in Table A.4, merchant ship construction is now concentrated in relatively few countries. Almost two-thirds of ships on order are in five countries -- Japan, Sweden, U.S., Brazil, and Spain.

TABLE A.4

MERCHANT SHIPS ON ORDER BY COUNTRY
AS OF JUNE 1977

Country	DWT on Order (000's of DWT)	% of Total Worldwide Orders
Japan	23,399	32.9
Sweden	6,621	9.3
U.S.A.	5,968	8.4
Brazil	5,130	7.2
Spain	4,786	6.7
Great Britain	3,918	5.5
France	2,906	4.1
Italy	2,036	2.9
Germany (GFR)	1,899	2.7
Total nine countries	66,288	79.8
World Total	71,044	100.0

Source: "Ships on Order", The Motor Ship, July 1977.

It should be noted that total deadweight tonnage alone does not indicate the relative value of shipbuilding business in any one yard or country. Shipbuilding must also be evaluated in terms of price or complexity of construction to reflect man-hours and materials -- though public availability of such contracting information is very limited in the maritime market.

Furthermore, as shown in Table A.5, the average size of ships on order or building has risen from about 30,000 DWT in 1967 up to 78,000 DWT in 1974 which reflects the increasing quantity of VLCCs (Very Large Crude Carriers) being constructed during that period. In 1976, the average size dropped to about 54,000 DWT which reflects a dearth of new VLCC orders and the current interest in ships of somewhat smaller size. By July 1, 1977, the average merchant ship was down to about 33,300 DWT.

To illustrate the effect of ship size, type and complexity on costs, the international price of constructing a 250,000 DWT tanker is approximately $250 per DWT, a 20,000 DWT container ship about $2000 per DWT, and a 35,000 DWT bulk carrier about $375 per DWT.

TABLE A.5

WORLD SHIPS ON ORDER OR BUILDING (1963-1976)
as of October 1 of each year
2000 DWT or larger

Year	No. of Ships	DWT (000)	Average DWT per Ship
1967	1,957	59,185	30,240
1968	1,822	69,066	37,900
1969	2,299	91,248	39,690
1970	2,593	114,190	44,040
1971	2,817	141,650	50,280
1972	2,276	138,162	60,700
1973	2,615	200,705	76,750
1974 Sept. 1	3,007	235,444	78,300
1975	2,720	166,981	61,390
1976	2,461	113,996	46,320
1977 July 1	2,133	71,044	33,310

SOURCE: "Ships on Order," The Motor Ship, July 1977

(3) Japan Is The Largest Shipbuilding Center, Accounting For One Third Of Merchant Ship Deadweight On Order

Japan has rapidly risen to be the largest commercial builder in the world with a current orderbook of about 33 percent of the international yearly tonnage of which 84 percent is for export, and has replaced the United Kingdom as the leader in this business during the post World War II period. There are over 70 shipyards building oceangoing vessels in Japan.

In the past several years, however, the Japanese shipbuilding industry has been hard hit by the slump in new construction and rise in labor costs. Orderbooks of Japanese shipyards are seriously depressed, and the Japanese government has been actively seeking ways to improve the situation. Japanese shipbuilders are actively pursuing investments in shipbuilding facilities in lower labor cost countries. Kawasaki, for example, has just negotiated a joint venture to build a large repair yard in the Philippines, and other Japanese yards have growing interest in other Philippine shipbuilding facilities.

(4) U.S. Shipbuilders Have The Third Largest Orderbook, Accounting For 8.4 Percent Of Merchant Deadweight Now On Order

In terms of percent of world deadweight tons on order, U.S. shipyards have risen from eighth to third place since 1972. This reflects an increase in the U.S. orderbook from 3.9 million DWT as of September 1972 to 6.0 million DWT as of July 1977. During the same period the world orderbook fell from 138 million to 71 million DWT.

(5) Northern European Shipbuilders Have Been Very Hard Hit By The Worldwide Ship Construction Slump

Sweden's orderbook has fallen to about one third the 1973 level. German shipbuilders' orderbook has fallen to about one quarter the 1973 level. These decreases in orders in hand have prompted broad policy studies by government offices responsible for maritime planning. There seems little doubt that substantial changes in the structure and number of shipyards are to result from the policy studies.

3. NAVAL SHIP CONSTRUCTION IS GEOGRAPHICALLY MORE CONCENTRATED THAN MERCHANT CONSTRUCTION, WITH THE UNITED STATES AND SOVIET UNION ACCOUNTING FOR MOST OF THE PRESENT ACTIVITY

Published statistics on naval construction are not as readily available as in the case of merchant work. But it can be concluded that naval construction is concentrated in few countries.

(1) Over The Period 1964-74 The Soviet Union And The United States Constructed 249 And 163 Naval Ships Respectively

During this period, dramatic increases in Soviet defense oriented spending was seen. In addition, the Soviet shipbuilding program was expanded to the extent that currently their navy consists of a larger number of ships that any other in the world. A major achievement of the Soviet building program occurred during 1970 when their nuclear submarine fleet exceeded that of the U.S. in number of ships.

Table A.6 provides a comparison of U. S. versus U.S.S.R. principal naval ships built during 1964 - 1974.

TABLE A.6

COMPARISON OF NAVAL SHIPBUILDING
U.S. VS. U.S.S.R. DURING 1964-1974

	Soviet	U.S.
Aircraft Carriers	0	2
Other Aviation Ships	2*	5**
Cruisers	16	16
Destroyers	27	6
Frigates (ocean escorts)	57	61
Nuclear Strategic Missile Submarines	45	28
Nuclear General Purpose Submarines	56	45
Conventional Submarines	46	0
TOTAL	249	163

* 2 Guided Missile - Helicopter Carriers (CHG)

** 5 Amphibious Assault Ships (LPH)

In addition to the principal combatants shown above, Soviet small combatants, auxiliaries, and other amphibious craft showed an increase of over 1,000 for that period while the United States increased by only 112.

Testimony on several occasions before the Defense Subcommittee of the Committee on Appropriations during 1977 revealed

additional facts regarding shipbuilding in the Soviet Union. The Soviets have the largest, most modern submarine yards in the entire world, having expanded from two to four yards since 1966. Additionally, almost all of the 11 principal Soviet building yards have undergone major modernization during the past five years. Currently only two shipbuilding yards in the United States are building nuclear submarines.

In the area of demonstrated capability, the Soviets have delivered over 800 surface combatants, amphibious craft and mine warfare compared to U. S. deliveries of 172. Admiral H. G. Rickover, U.S.N. stated in his testimony before the House Appropriations Committee on March 24, 1977 that the Soviets have a "nuclear submarine production capability of 20 ships a year on a single shift basis". Further evidence of Soviet accomplishments in shipbuilding is seen in the fact that currently the Soviet fleet of nuclear ballistic missile submarines is 50 percent larger than that of the U. S. The Soviet shipbuilding industry is delivering SSBNs at a rate of six per year. The U. S. on the other hand has not delivered any SSBNs in the past ten years. Current U. S. submarine programs are based on a projected combined delivery rate of three to four SSN/SSBNs per year.

(2) Other Countries Are Constructing Naval Ships, But Not On The Same Scale As The U.S. And U.S.S.R.

A review of "Jane's Fighting Ships" 1976-1977, reveals that the primary nations having naval ships built at this time number approximately 30. The countries showing the largest current building programs include:

Country	Total Number Being Constructed	Number of Total Significant Combatants*
People's Republic of China	58	14
United Kingdom	30	16
France	25	21

* Includes carriers, cruisers, destroyers, frigates, corvettes, submarines.

As shown in Table A.7, U.S. naval ship construction activity is much greater than that of other free-world nations. The U.S. program planned for FY 1978 is about $6 billion -- as compared to $3.7 billion for 1976. No comparable increase appears to be planned in the other NATO countries.

TABLE A.7

COMPARISON BY COUNTRY OF NAVAL EXPENDITURES
(In Millions of U.S. Dollars)

	1972	1974	Increase (Decrease) 1972 - 1974
United States	$3013.2*	$3508.4*	$495.2
Belgium	11.7	26.9	15.2
Denmark	17.1	43.7	26.6
West Germany	170.1	204.8	34.7
Italy	29.6	73.5	43.9
Netherlands	46.2	121.7	75.5
United Kingdom	396.2	446.1	49.9

	1974	1976	Increase (Decrease) 1974 - 1976
United States	$ 3508.4	$3928.0*	$ 419.6
Belgium	26.9	52.0	25.1
Denmark	43.7	51.8	8.1
West Germany	204.8	253.3	48.5
Italy	73.5	83.9	10.4
Netherlands	121.7	92.3	(29.4)
United Kingdom	446.1	435.6	(10.5)

* Sources for United States figures:

(1) Historical Budget Data; April 1976; OP924E5 U.S. Navy pg. 50

(2) Department of Defense Appropriations of 1977; Hearings before Subcommittee of the Committee on Appropriations - House of Representatives, Part 5 Procurement; March 1976 pg. 641

The number of naval ships being constructed or planned in all NATO countries is shown in Table A.8. Although a few countries have ambitious current programs and future plans, the general reliance on U. S. naval strength is obvious.

TABLE A.8

SUMMARY OF NAVAL SHIPBUILDING
UNDERWAY IN NATO COUNTRIES
(including France, but excluding United States)

Country	Type Ships	Number Building
Belgium	Frigates	4
Canada		None
Denmark	Fast Attack Craft (Missile)	6
	Nine Layers	2
France	Helicopter Carrier-Nuclear	Planned
	Destroyers	4
	Frigates	11
	Submarines-Missile	2
	Submarines - fleet	1
	Submarines - Patrol	3
	Fast Attack Craft-Missile	1
	Tankers	1
	Small Transports	2
Greece	Patrol Submarines	3
Italy (2)	Frigates	4
	Submarines	2
	Hydrofoil-Missile	6 Planned
Netherlands	Frigates	4
	Frigates	9 Planned
	Mine Hunters	15 Planned
	Surveying Vessels	1
Norway	Fast Attack Craft-Missile	14
	Mine Hunters	2
	Depot Ships	1
	Coast Guard Vessels	8
Portugal		None
Turkey	Submarines - Patrol	3
	Fast Attack Craft - Missile	4
	Large Patrol Craft	1

Country	Type Ship	Number Building
United Kingdom	A/S Carriers (Cruisers)	2
	Destroyers	5
	Frigates	6
	Submarine - Fleet	3
		1 planned
	LCT's	2
	Offshore Patrol Craft	4
	Large Patrol Craft	3
	Mine Hunters	2
	Fleet Replenishment Ships	2
	Store Carriers	1
West Germany	Frigates	12 planned
	Fast Attack Craft-Missile	4
		6 planned

Notes:

(1) Denmark - Additional Construction Planned

Corvettes	6
Submarines	6
Minelayers	2
MCM Vessels	4
Mine transports	3
Fast Attack Craft	24

(2) Italy - tentative new construction 1975-84

Helicopter Cruiser	1
Guided Missile Destroyer	2
Frigate	8
Submarines	2
Mine Hunters	10
Hydrofoils	9
NATO Hydrofoils	4
LPD's	1
Replenishment Tanker	1
Tugs	17

Source: Jane's Fighting Ships 1976-1977

4. <u>THE U.S. SHIPBUILDING INDUSTRY IS A HIGHLY CONCENTRATED INDUSTRY LARGELY DEPENDENT ON GOVERNMENT GENERATED PROGRAMS</u>

Considerable information has been published in recent years on the U.S. shipbuilding and repair industry. The Report of the Commission on American Shipbuilding dated October 1973, the 1974 Hearings of the Seapower Committee of the House Armed Services Committee, and the Annual Report on the Status of the Shipbuilding and Repair Industry of the United States 1976, by the Coordinator of Shipbuilding, Conversion and Repair, Department of Defense (DD - I & L (A) 1141), are all excellent summaries of the industry and the nature of its work.

(1) <u>U.S. Shipbuilding Is A Moderate Sized Industry And Is Not A Major Factor In The World Export Market</u>

Virtually all commercial tonnage constructed in the United States is for U.S. flag operation, either under financial aid programs or under the protection of cabotage laws which specify all intercoastal and non-contiguous traffic must move in domestically built ships. The industry's consistently largest customer has been the U.S. Navy. In addition, most U.S. owners desire specially designed ships. As a result, many yards have a greater capability to build one-of-a-kind of the more sophisticated ships than for mass-production

as is more common abroad.

U.S. shipyards are normally unable to compete in the international market. Only during critical periods, such as the closing of the Suez Canal, when foreign yards were unable to accept new tanker orders, did the U.S. enter the export market. Similarly, in the late 1960's and early 1970's, the advanced technology in the design and construction of oil drilling rigs and off-shore supply boats enabled the U.S. yards to build these for export. The foreign shipyards have since acquired this expertise and these marine platforms and vehicles are now competitively built abroad. There has been a recent increase, however, in the sale of U.S. built, sophisticated naval ships to foreign nations, such as Saudi Arabia, Australia and others.

The industry is defined by the Standard Industrial Classification Manual (SIC Code 3731) as:

> "Establishments primarily engaged in building and repairing all types of ships, barges and lighters, whether propelled by sail or motor power or towed by other craft. This industry also includes the conversion and alteration of ships. Establishments primarily engaged in fabricating structural assemblies or components for ships, or subcontractors engaged in ship painting, joinery, carpentry work,

electrical wiring installations, etc. are classified in other industries."

(NOTE: Boat building and repairing are excluded and are in a separate category, SIC Code 3732.)

As of March 1, 1977, private shipyards employed 175,500 workers and U.S. Naval Shipyards employed 67,500 workers. Table A.9 shows various production trends for the industry over the past 11 years.

U.S. shipyards are becoming increasingly dependent upon naval shipbuilding work, especially with the current reduction in commercial shipbuilding backlogs. Historically, most yards have concentrated on either commercial or naval work with a preference for commercial work. Others will combine these programs as a means of maintaining labor continuity and lower overhead. Dual programs usually require additional work skills and separate management teams which increase costs and add complications.

Such yards as Newport News and General Dynamics-Electric Boat are involved in the construction of complex nuclear naval ships with Newport News also undertaking major commercial construction. Ingalls/Litton, formerly involved in building nuclear submarines, is now emphasizing the construction on non-nuclear destroyers (DD)

TABLE A.9

SHIPBUILDING AND SHIP REPAIR: TRENDS AND PROJECTIONS 1967-1977

(In Millions of Dollars Except As Noted)

	1967	1972	1973	1974	1975 (1)	1976 (1)	1977 (1)
Industry (2)							
Value of Work Completed (4)	2,513	3,279.0	3,962.6	4,825	5,058	5,365	5,825
Total employment (000)	138.8	144.6	152.3	162.3	162.6	172.9	170.0
Production workers (000)	114.2	118.0	120.8	129.0	129.0	137.0	134.0
Value Added	1,609.8	1,881.3	2,218.0	2,547.4	2,670	2,830	3,075
Value Added per Worker Manhour ($)	7.8	8.1	9.3	10.1	n.a.	n.a.	n.a.
Product (3)							
Value of Work Done	2,358	3,188	3,888	4,712	4,940	5,240	5,690
Non-propelled New Ships	149	362	386	460	480	500	450
Self-propelled New Military Ships	947	1,092	1,333	1,714	1,840	2,100	240
Self-propelled New Non-military Ships	362	816	1,202	1,290	1,300	1,200	1,200
Repair of Military Ships	423	384	393	533	620	730	910
Repair of Non-military Ships	407	482	523	713	695	705	725
Shipbuilding and Repair, n.s.k.	43	53	52	2	5	5	5

NOTE: Preliminary
n.a. - not available
n.s.k. - not specified by kind

(1) Estimated by MarAd and Shipbuilders Council of America
(2) Includes value of all products and services sold by shipbuilding and repair industry
(3) Includes value of work done on ships only
(4) Comparable to industry shipments

SOURCE: Bureau of Census, Bureau of Labor Statistics, MarAd, Shipbuilders Council of America

and amphibious assault ships (LHA). Yards such as Todd and Bath are constructing a mix of commercial and naval ships with an historic preference for naval ships.

Others such as Avondale, Bethlehem, NASSCO and General Dynamics (Quincy) have built or are building both types, but usually appear to prefer commercial work when available. On the other hand, Sun, Seatrain and the large Great Lakes shipyards have indicated little interest in naval ships. In the overall, the type of ship construction being undertaken will depend upon the availability of work, hence the shipbuilding industry is highly dependent upon a continuity of military work and subsidized construction.

The U.S. shipyard value of yearly unfinished new construction work on merchant ships (1,000 gross tons and larger) and naval ships (1,000 light displacement tons and larger), as of January 1, 1977, is shown in Table A.10. The value of yearly unfinished work has grown from \$2.3 billion in 1967 to \$9.9 billion in 1976, with a slight anticipated reduction to \$9.7 billion during 1977.

The Shipbuilders Council of America has forecast that in the January 1, 1977 to December 31, 1981 period, the average yearly U.S. shipyard revenues (value of work done excluding customer

TABLE A.10

MERCHANT AND NAVAL VESSELS
BUILDING OR ON ORDER IN PRIVATE U. S. SHIPYARDS

Ships of 1,000 Gross Tons and Larger
(As of January 1, 1977)
(Dollars in Millions)

Year	Merchant Vessels Value of Unfinished Work	Naval Vessels Value of Unfinished Work	Total Value of Unfinished Work
1967	$ 543	$1,751	$2,294
1968	788	1,649	2,437
1969	800	1,700	2,500
1970	765	1,719	2,484
1971	765	1,925	2,690
1972	1,058	2,225	3,283
1973	2,950	3,160	6,110
1974	3,770	3,603	7,373
1975	4,350	5,424	9,774
1976	3,400	6,500	9,900
1977	2,930	6,802	9,732

SOURCE: Shipbuilders Council of America

furnished material and nonship products) will come within the following ranges:

Estimated Annual Average (Millions of Dollars)

MERCHANT FLEET

	Low	High
Ship Construction		
Tankers	$ 250	$ 420
LNG Carriers	160	250
Dry Cargo/Other Oceangoing Ships	65	235
Small and Nonpropelled Ships (including barges)	420	580
Great Lakes Ships	80	100
Ship Repair & Conversion	500	800
Subtotal	$1,475	$2,385

NAVAL FLEET

Ship Construction & Conversion	$1,900	$2,300
Ship Repair & Alteration	650	850
Subtotal	$2,550	$3,150

OTHER SHIPWORK

Offshore Drilling Units (including production platforms)	50	150
U.S. Coast Guard, Corps of Engineers, Fisheries, etc.	80	200
Subtotal	$ 130	$ 350
Aggregate Total	$4,155	$5,885

(2) <u>Average Employment In Private Yards Has Increased 28 Percent Between 1971-1976, Reflecting The Higher Level Of Ship Construction Activity</u>

The impact of the Merchant Marine Act of 1970 and the larger naval building program is found in shipyard employment data. Table A.11 indicates employment over the past several years in major private shipyards throughout the five shipbuilding regions in the United States. Increases in average shipyard employment have been significant over the past five years, particularly in light of general stagnant economic trends during this period. The greatest increase (31 percent between 1971-76) has taken place in East Coast shipyards.

Naval shipyard employment is shown in Table A.12. Employment levels started a decline in 1969 which continued through 1973 and have remained relatively steady since then. The figures reflect the closing of two shipyards and the cessation of new naval ship construction. The eight remaining Naval Shipyards are presently confined to the overhaul and conversion of naval ships which represents about two-thirds of the total yearly Navy ship repair and conversion budget, with the balance allotted to commercial shipyards.

TABLE A.11

AVERAGE PRIVATE SHIPYARD EMPLOYMENT 1966-1976
(in thousands)

Year	Total	North Atlantic	South Atlantic	Gulf	Pacific	Great Lakes & Inland
1966	143.6	52.6	24.8	35.6	20.7	9.9
1967	140.0	48.4	26.1	34.8	20.7	10.0
1968	141.0	46.2	27.0	36.5	22.4	8.9
1969	142.0	45.8	26.0	37.6	25.2	7.4
1970	132.7	43.6	23.2	38.8	20.3	7.6
1971	130.6	40.4	23.3	43.2	16.4	7.3
1972	138.1	39.3	28.9	46.6	15.7	7.6
1973	143.9	39.5	29.8	48.7	16.9	8.9
1974	154.9	44.7	27.7	48.9	22.8	9.7
1975	153.6	49.2	25.4	45.0	24.9	9.2
1976	166.8	56.9	26.5	45.2	26.6	11.6

SOURCE: Shipbuilders Council of America, Statistical Quarterly, First Quarter 1977

TABLE A.12

NAVAL SHIPYARD AVERAGE EMPLOYMENT
(All Employees in Thousands)

Year	Total	Boston (1) Portsmouth, Philadelphia	Norfolk, Charleston	San Francisco Puget Sound Los Angeles Pearl Harbor
1966	85.4	25.5	19.3	40.6
1967	94.5	27.8	21.5	45.2
1968	95.2	28.5	21.7	45.0
1969	91.0	27.6	20.6	42.8
1970	83.0	24.4	19.1	39.5
1971	75.5	20.8	18.5	36.2
1972	70.1	18.7	17.7	33.7
1973	64.5	16.1	17.3	31.1
1974	64.4	13.7	18.5	32.2
1975	64.6	13.4	18.6	32.6
1976	65.4	13.7	18.9	32.8
1977 (Mar.)	67.5	14.2	19.5	33.8

(1) Hunter's Point closed June 29, 1974 and Boston closed July 1, 1974.

SOURCE: Shipbuilders Council of America, Statistical Quarterly, First Quarter 1977, Bureau of Labor Statistics

(3) <u>Over The Past Ten Years, Material And Wage Escalation Has Been A Major Factor In Driving Up U.S. Shipbuilding Costs</u>

In the period of 1967 through 1976, U.S. shipbuilding and ship repair average hourly earnings have increased from $3.44 to $6.01 per hour, or a total of 74 percent (see Table A.2). The annual rate of increase has been accelerating during the 1974 to 1976 period. These hourly earnings do not include fringes which have been increasing at twice the annual rate of earnings. Fringes over the past six years in a major U.S. shipyard had a compounded average growth of 13.8 percent per year as compared to 6.3 percent for direct labor pay. In 1975, they averaged 35 percent of the annual pay of direct employees.

Shipbuilding materials, as measured by the weighted BLS shipbuilding material index, have also increased at a high rate in the same 1967-1976 period. This index increased 95 percent, which is higher than the 82 percent increase in the wholesale industrial price index over the same period and considerably higher than the consumer price index (see Table A.13). The Navy advises that ship components and certain materials have increased at a rate greater than the BLS material index. This is partly borne out by the Iron and Steel (Group 10-1) Index which increased 116 percent

TABLE A.13

MATERIAL COST INDICES
(Average for Year)

Year	Wholesale Price		Iron & Steel (1)		BLS Shipbuilding Material (2)	
	Index	Percent Yearly Increase	Index	Percent Yearly Increase	Index	Percent Yearly Increase
1967	100.0	-	100.0	-	100.0	-
1968	102.5	2.5	101.9	1.9	102.2	2.2
1969	106.0	3.4	107.0	5.0	106.5	4.2
1970	110.0	3.8	115.1	7.8	113.4	6.5
1971	114.0	3.6	121.8	5.8	118.9	4.9
1972	117.9	3.4	128.4	5.4	123.3	3.7
1973	125.9	6.8	136.2	6.1	128.9	4.5
1974	153.8	22.2	178.6	31.0	159.6	23.8
1975	171.5	11.5	201.1	12.6	182.9	14.6
1976	182.3	6.3	215.9	7.3	195.0	6.6
Increase 1967-76	82.3%		115.9%		95%	
Average Annual Growth	6.9%		8.0%		7.7%	

(1) Group 10-1 of Wholesale Price Index
(2) BLS Weighted Shipbuilding Index used for contract escalation

SOURCE: Bureau of Labor Statistics

over 1967-1976. The average annual growth rate for the Wholesale Price Index was 6.9 percent, the Iron and Steel Index was 8.0 percent, and the BLS Index was 7.7 percent. This shows 1974 and 1975 as being critical material inflation years.

The Maritime Administration in its Reports to Congress on "Relative Cost of Shipbuilding in the Various Coastal Districts in the United States" for 1973, 1974, 1975, 1976 and 1977 has established basic costs of an 89,000 DWT tanker for yearly comparisons. In this five year period, it was estimated that shipbuilders' costs had increased 86 percent. The cost of ship's steel had increased 68.1 percent. Total ship material costs increased approximately 95 percent, with an annual growth rate of 18.5 percent, which is considerably greater than any of the aforementioned indices. A comparison of the various material growths over the past five years indicates the following:

	Increase 1972-1976	Average Annual Growth Rate	1976 Growth Rate
MarAd Material Increase (FY 1973-1977)	95.0%	18.5%	6.5%
Wholesale Price Index	54.6%	10.9%	6.3%
Iron and Steel Index (10-1)	68.1%	13.6%	7.3%
BLS Material Index	57.0%	11.4%	5.8%

Thus, most shipbuilding materials are increasing at a greater rate than indicated by both the Wholesale Price and BLS Material Indices.

During the critical inflationary period, the term double-digit was a misnomer by implying inflation somewhat in excess of ten percent. In reality, many selected materials increased inordinately in one year. The impact of this inflationary period on the shipbuilding industry has been understated and underestimated. Its impact is still being felt in current prices of ships.

(4) New Commercial Ship Construction Orders In The U.S. Are Dropping From The 1974-1976 High Period

As of January 1, 1977 there were 71 merchant ships (1000 gross registered tons (grt) or larger) on order or under construction totaling 4,200,923 grt, most of which are being constructed with government financial assistance. This is a reduction from 96 ships totaling 5,064,011 grt two years earlier. All things considered, however, the merchant shipbuilding program has expanded considerably under the revised Merchant Marine Act of 1970. In addition, the average size of ships built in the U.S. has materially increased, due basically to the construction of larger tankers. At present many shipyards are working off their backlogs, and the orderbook as of

January 1, 1977 has decreased considerably from the 1975 peak.

The present highly competitive nature of dry and bulk cargo shipping has forced down charter rates and many U.S. operators are hesitant to expand or replace their fleets at this time, other than those engaged in carrying oil in the coastal trades. There are, at present, considerable government appropriated subsidy funds available from prior budget years, with only limited operator interest. Enactment of cargo preference laws would result in additional commercial ship construction, depending upon the percentage of cargo to be carried in the U. S. flag built vessels.

U.S. Merchant shipbuilding trends in the 1966-1977 period are shown in Table A.14.

(5) More Than Half Of New United States Construction Is For Naval Ships

As of January 1, 1977, the U.S. private yards had on order or under construction 88 Naval ships (1000 light displacement tons and over) totaling 712,000 light displacement tons (ldt). Comparable figures on January 1, 1976 were 76 ships of 690,000 ldt. The Naval shipbuilding program has been greatly increased for Fiscal Year 1978, and it would appear to assume a continuation at this high rate over the next few years. These programs should utilize

TABLE A.14

MERCHANT VESSELS BUILDING OR ON ORDER IN PRIVATE SHIPYARDS
Ships Of 1,000 Gross Tons And Larger
(as of January 1977)

Year	Number of Ships	Tons in Thousands (grt)	Approximate Value of Unfinished Work (Dollars in Thousands)
1966	45	551	501,000
1967	48	634	543,000
1968	64	1,221	788,000
1969	63	1,506	800,000
1970	49	1,399	765,000
1971	49	1,609	765,000
1972	59	1,819	1,058,000
1973	88	2,879	2,950,000
1974	97	4,010	3,770,000
1975	96	5,064	4,350,000
1976	79	4,649	3,400,000
1977	71	4,200	2,930,000 (1)

(1) Estimated

SOURCE: Shipbuilders Council of America

some of the surplus capacity becoming available through the present reduction of commercial shipbuilding orders. However, enactment of cargo preference legislation would limit the number of potential yards interested in undertaking naval construction.

Table A.15 indicates the trend of Naval shipbuilding in the U.S. since 1966, as well as the approximate value of unfinished work for each year.

The number of ships and tonnage does not necessarily reflect the complexities of the programs. Naval ships may be relatively small in terms of tonnage, yet require high cost equipment and considerable skilled shipyard labor, hence resulting in a very high cost per ton per ship.

(6) Naval Ships Are Considerably More Complicated Than Commercial Ships And Therefore Require Greater Technical And Industrial Skills

Design and construction of naval ships is more complex than for commercial ships. The technologies and skills used in construction of normal merchant ships usually include the following:

- Naval architecture
- Marine engineering

TABLE A.15

NAVAL VESSELS BUILDING OR ON ORDER IN PRIVATE SHIPYARDS

Ships Of 1,000 Light Displacement Tons And Larger

(as of January 1, 1977)

Year	Number of Ships	Tons in Thousands (ldt)	Approximate Value of Unfinished Work (Dollars in Thousands)
1966	106	573	1,387,000
1967	147	745	1,751,000
1968	134	686	1,649,000
1969	133	701	1,700,000
1970	108	621	1,719,000
1971	82	588	1,925,000
1972	64	529	2,225,000
1973	57	520	3,160,000
1974	56	526	3,603,000
1975	63	659	5,424,000
1976	76	690	6,500,000
1977	88	712	6,802,000(1)

(1) Preliminary

SOURCE: Shipbuilders Council of America

- Electrical and electronic engineering
- Allied engineering fields
- Steel fabrication and erection
- Machinery assembly and installation
- Electrical, electronic, navigational equipment installation and interconnection
- Piping system installation
- Joinery and carpentry in crew quarters and work spaces
- Outfitting
- Coating specialists

Naval ships are broadly divided into support or auxiliary ships and combatant ships. In general terms, support ships resemble merchant ships, with the addition of some special features inherent in combatant ships. The most complex ships are in the combatant category which require many skills well in excess of those usually encountered in a strictly commercial yard or yards constructing only naval auxiliary ships. Depending upon the ship type (DD's, CV's, SSN's, LHA's, AD's, AOR's, etc.), the added technologies and skills over those required for commercial ships could include:

- More refined naval architecture
- Ship silencing and shockproofing

- Specialized electronic and weapon engineering
- Nuclear engineering
- Higher degree of planning
- Installation of more complex machinery
- Integration, installation and interconnection of electronic and weapon equipment
- More extensive checkout, testing and quality control
- Integration and installation of avionic equipment and aircraft landing and recovery equipment
- Special qualifications in assembly and joining of pressure hull materials
- Extensive metallurgical engineering
- Fabrication, installation and welding of materials for nuclear systems

A significant portion of the naval ship cost is represented by Government Furnished Material (GFM) such as weapons, communication system, propulsion systems, special machinery, etc. In addition to group procurement cost saving, these are frequently long lead items, or those that require some degree of technological development. Thus they may be ordered well in advance of awarding the ship construction contracts. Notwithstanding long range GFM procurement planning, it is sometimes desirable to make equipment changes during planning and on occasion during construction.

5. COSTS OF SHIP CONSTRUCTION WORLDWIDE HAVE SHOWN MARKED INCREASES OVER THE PAST TEN YEARS

International shipbuilding labor and material costs have risen significantly over the past ten years, and depending upon the market conditions and degree of governmental direct and indirect support, the price of ships will continue to increase over the foreseeable future. Furthermore, these price increases are not always uniform, which affects the competitive balance among world shipbuilders.

(1) Inflation In Labor And Material Has Been A Major Cost Driver For Ship Construction

As shown in Table A.16, Swedish labor costs are now the highest in the world, surpassing those in United States shipyards. Labor costs in Japan, Germany, Netherlands and United Kingdom have also risen substantially, especially since the 1970's, which reflect varying exchange rates and inflationary trends over the past few years. During the period of 1966 through June 1976, U.S. average hourly earnings in shipbuilding and repair yards have increased about 74 percent, whereas hourly earnings (in dollars) in Sweden, Netherlands, United Kingdom and Japan have increased between 172 to 406 percent.

TABLE A.16

AVERAGE HOURLY EARNINGS IN MAJOR SHIPBUILDING COUNTRIES
1967-1976
(in U. S. dollars*)

Year	United States	Sweden	United Kingdom	Japan	Netherlands	West Germany
1967	3.44	2.45	1.16	0.75	1.12	1.31
1968	3.58	2.58	1.27	0.80	1.21	1.35
1969	3.81	2.82	1.40	0.90	1.32	1.62
1970	3.96	3.11	1.57	1.07	1.49	1.80
1971	4.12	3.40	1.85	1.25	1.81	2.12
1972	4.36	4.19	2.01	1.49	2.17	2.51
1973	4.61	4.95	2.33	2.00	2.81	3.36
1974	4.98	5.44	2.72	2.64	3.44	3.87
1975	5.51	6.41	3.43	3.24	4.20	4.33
1976	6.01	7.05	3.16	4.05	4.33	4.42
Percent Increase 1967-76	74	187	172	406	286	237

* Does not include fringes

SOURCE: Bureau of Labor Statistics -- Foreign Comparison Branch

U.S. News and World Report in its July 18, 1977 issue comments on soaring wage scales as follows:

> "Soaring wage scales, big fringe benefits boost hourly labor costs. Chase Econometrics figures for 1977: Sweden, $9.38; Belgium, $8.71, with Americans, once the highest paid, in third place at $8.48, followed by Holland's $8.05.
>
> Belgians are expected to take the lead in 1978 and keep it through 1980. By then, the U.S. will have slipped to fourth place. Decade's-end forecast -- Belgium, $11.87; Sweden, $10.75; Netherlands, $10.68; the U.S., $10.23.
>
> The upswing in Belgian and Dutch labor rates is due to escalator pacts that tie wages to rising living costs. Figures published by the European Common Market Commission show Belgium's labor-unit costs between 1973 and 1976 hurtling upward almost twice as fast as in the U.S. or West Germany."

Material costs have also been affected by inflationary pressures. Table A.17 indicates that major shipbuilding countries have had wholesale industrial price increases in the range of 54 to 87 percent over the past ten years. Most of these increases occurred in the 1971 - 1975 period, with West Germany and Netherlands showing the least material inflation and the United States' increases being of similar magnitude to those of Japan, Norway, Sweden and France.

Inflationary labor and material costs must be borne by the shipyard and have driven the upsurge in ship prices witnessed in recent years. The Maritime Administration Annual Report to Congress on the

TABLE A.17

WHOLESALE INDUSTRIAL PRICE INDEX
(1966-1976)

Country	France	Germany	Japan	Nether-lands	Norway	Sweden	U.S.
Base Year = 100	1962	1970	1970	1970	1961	1968	1967
1966	110.2	90.3	92.7	95	112	103	98.5
1967	109.2	89.4	93.8	96	113	101	100.0
1968	107.4	92.8	94.1	98	115	100	102.5
1969	118.9	95.0	95.9	96	120	104	106.0
1970	127.8	100.0	100.0	100	129	112	110.0
1971	130.5	104.3	98.9	104	129	114	114.0
1972	136.5	107.0	99.7	110	133	119	117.9
1973	156.6	114.1	114.8	117	147	133	125.9
1974	202.2	129.4	147.3	129	179	165	153.8
1975	190.8	135.5	149.6	135	187	178	171.4
1976	204.8	140.8	156.8	146	201	193	182.3
Percent Increase 1966-75	86	56	69	54	79	87	85
Percent Increase 1971-76	57	35	58	40	56	69	60

SOURCE: Bureau of Labor Statistics

Relative Cost of Shipbuilding in the Various Coastal Districts of the United States indicates that the base cost to a shipyard of constructing an 89,000 DWT commercial tanker in an East Coast shipyard has risen from $25 million (without profit and escalation) as of June 1973 to $46.5 million (without profit and escalation) as of June 1977. This is an increase of 86 percent over a four year period.

A United Kingdom trade journal, Fairplay International Shipping Weekly, has over many years estimated the cost of constructing a standard 15-knot austere general cargo ship of 13,000 DWT. In a five year period, the cost has increased approximately 200 percent.

(2) Increased Ship Complexity Has Also Added To Overall Costs

Cost increases in acquiring new ship tonnage have also resulted from numerous improvements necessary to meet present day operating requirements and competition. Typical of these cost drivers are:

- mechanization
- single room crew berthing and overall improvement in accommodations
- higher power and speed
- maintenance reducing features such as improved coatings, special materials, etc.
- ship construction features for added safety and pollution abatement

- modern safety and navigational equipment
- more efficient cargo handling equipment
- EPA and OSHA

Similar cost drivers have also affected naval ship prices, plus the added costs of improved weapons systems.

(3) Market Condition Has A Great Impact On Final Price Determination

Actual selling prices are not always related to cost, but strongly reflect market and other shipyard business conditions. Some of the more significant factors, other than actual cost, affecting ship price determination are:

- market conditions
- need for new work
- degree of direct and indirect government assistance
- future follow-ship opportunities
- customer relationships
- competition
- risks of escalation
- currency exchange rates

Evidence of this is found in the fluctuating price structure of the popular 60,000 DWT "Panamax" Bulk Carriers, which are capable of transiting the Panama Canal under full load. Table A.18 indicates price trends of these ships being constructed in Japan during 1966 through 1976, with international competition reflected in the $300 per

TABLE A.18

TRENDS IN JAPANESE SHIPBUILDING PRICES
For 60,000 DWT "Panamax" Bulk Carriers

Year	$/DWT	Year	$/DWT
1968	$ 125	1973	$ 225
1969	150	1974	325
1970	185	1975	375
1971	175	1976	300
1972	175		

SOURCE: Trade Journals

DWT price in 1976. When related to labor and material inflation trends, the drop in ship prices appears unrealistic. European shipbuilders are accusing the Japanese of dumping ships on the international market at below construction costs.

As shown in Table A.18, the price of the "Panamax" Bulk Carrier was considerably less in 1976 than in 1975, despite increases in labor and material costs. In a seller's market, many international shipyards have made tremendous profits, often to be followed by retrenchments in a buyer's market.

(4) <u>Ship Prices Are Also Affected By Direct And/Or Indirect Assistance Programs Of Various Governments</u>

Government financial assistance to the maritime industry is pervasive in the international shipbuilding community. This direct and indirect assistance varies in magnitude. This issue of these aids has been discussed in several international bodies.

The government aids may include some of the following in varying forms, and may be granted to ship owners, ship operators, shipbuilders, and manufacturers of marine materials and equipment:

- Direct ship operating subsidies to encourage additional national ship construction

- Direct ship construction subsidies
- Obsolete ship trade-in allowances
- Official loan guarantees covering a substantial portion of the cost
- Loans with interest at less than commercial rates for domestic and/or export sales
- Special accelerated depreciation rates
- Tax-free reserve funds used for new ship construction
- Government sponsored ship replacement program
- Military ship procurement, conversion and repair
- Duty free imports of materials and equipment for ship construction
- Cargo preference schemes for national flag ships
- Material price controls and price structuring
- Government funding of marine R & D
- Laws requiring construction of national flag ships in domestic yards for operation in nations' foreign and domestic trade.
- Laws specifying that materials and component parts for the construction of ships and their maintenance and repair, as well as for food, stores and supplies be purchased within the ship flag country.

Attempts to regulate, standardize or abandon this assistance have been limited, especially as each of the competing nations is faced with a curtailment of its shipbuilding activities. International over-

production has been known and anticipated over the past several years. Notwithstanding, the major countries, including Japan, have continued to expand facilities and have been unwilling to face the inevitable. Very recently, the Japanese government has agreed on a gradual reduction of shipbuilding in future years. In addition, new emerging shipbuilding countries also provide forms of financial assistance or preferential cargo laws in the hope of establishing a future self-supporting maritime industry. This cannot be assured and may well result in financial loss in the highly competitive international maritime industry.

6. COST ESTIMATING DIFFICULTIES HAVE BEEN EXPERIENCED BY ALL SHIPBUILDERS DUE TO UNPREDICTABLE MOVEMENTS IN LABOR AND MATERIAL COSTS

As was discussed in the preceding section, labor and material costs in ship construction have been increasing significantly over the past decade. But more important to this study is the fact that the rate of cost growth has not been consistent. Many shipbuilders throughout the world have felt the consequences of trying to make accurate cost projections in a period of erratic shifts in the cost of factor inputs.

(1) The Relatively Consistent Growth In Labor And Material Costs In The 1960's And Early 1970's Has Been Replaced By An Erratic Pattern Over The Past Five Years

Labor and material cost in the major shipbuilding countries tended to exhibit fairly consistent growth patterns between 1966-1972. There are exceptions, of course. But perusal of Tables A.16 and A.17 will indicate a relatively predictable, consistent pattern of increase existed during this period.

Between 1972-74 both material and labor costs took a big jump in all shipbuilding countries. Japanese labor costs, for example, increased $1.24 per hour during this period -- an increase of 62 percent. Material costs in Japan (as reflected by the whole-sale industrial price index) increased over 47 percent during the same period. Increases of similar nature were experienced by European builders.

(2) The Erratic Pattern In Labor And Material Costs Has Created Problems In Estimating In Japan

According to a senior cost estimating official at Kawasaki Heavy Industries, estimates made by Kawasaki prior to 1973 "were generally within 2-3 percent of the final price." But the unex-pected rise in labor and material costs in the period immediately

following the "oil shock" resulted in estimates "20 percent under the final delivered price." According to this official they had estimated escalation of material at 8-10 percent annually -- whereas actual experience was a sudden increase of 30 percent in a one year period following the "oil shock."

Then the situation reversed itself. In an attempt to take the more rapid factor cost increases into account, the firm "has over-estimated recent ships by 10-12 percent." They had not anticipated the sudden leveling-off in both labor and material costs.

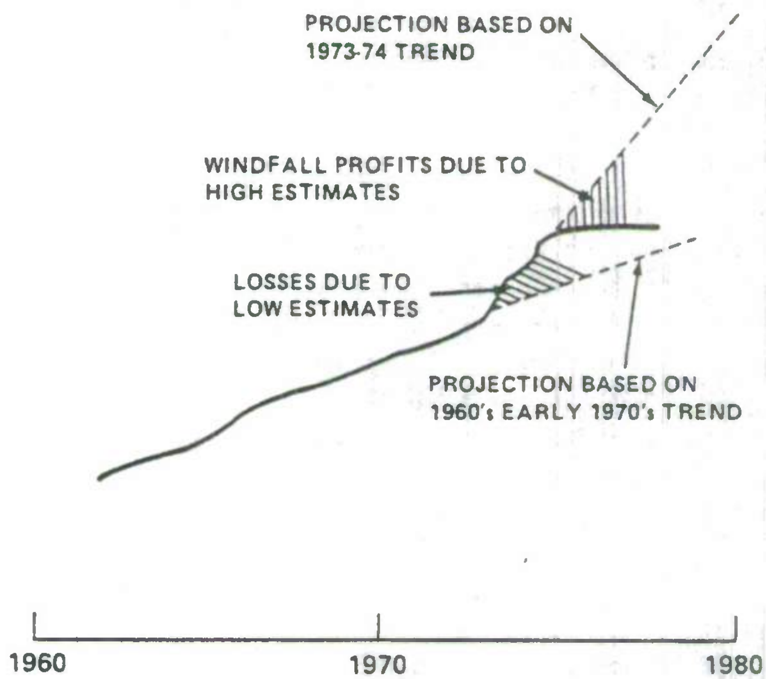
The situation experienced by Kawasaki is graphically shown in Figure A.1.

As a result of this more erratic pattern, Kawasaki now makes a thorough in-house review of economic trends every three months. This forms the basis for cost projections for estimating purposes. Previously it was considered adequate to update the economic review once a year.

An official at Mitsubishi reports similar experience encountered by his firm. The oil shock caused a 20-30 percent jump in the actual cost -- whereas the estimate was based on a much lower

FIGURE A.1

KAWASAKI COST ESTIMATING EXPERIENCE



SOURCE:
INTERVIEW WITH FIRM OFFICIAL

historical trend projection. This official indicated that the financial consequences of the low estimate were muted by the fact that substantial profit margins had been attached to estimates made in the period immediately preceding the oil shock. "Losses due to underestimates would have been much greater had the profit cushion not existed."

IHI, a major Japanese shipbuilder, reports in its 1975 Annual Report to Shareholders that:

> "A characteristic of our products is the considerable time lag elapsing between receipt of an order and delivery of the finished article. Thus, while deliveries made on orders received in past years bolstered our turnover, the resulting profits were squeezed down by the 23 percent rise in wholesale prices that came after the oil crisis, which inflated our production and operating costs beyond all expectations. As a result, net earnings decreased by 18.5 percent to ¥ 6,800 million.

Seatrade Magazine reported in late 1973 that "Most of the larger shipbuilders in Japan have decided to put a freeze on the signing of new contracts, especially for large ships. This is because orderbooks stretch into 1978, and the modern, much quickened pace of inflation makes it extremely difficult to calculate profit margins in fixed-price contracts."*

* Seatrade, December 1973.

A more recent article in Zosen provides evidence of the over-estimates that followed the under-estimates in 1974-75. In reporting the 1976 business results of the top seven shipbuilding companies,* it states that "whereas the combined total of the seven's gross sales represented a gain of 9.8 percent over the fiscal 1975 figures, that of their recurring profits jumped 45.1 percent." The four reasons cited for this improved profit performance are:

> "Most new buildings which were undertaken with relatively high profit margins contracted for in the wake of the late 1973 oil crisis were completed and entered into fiscal 1976 earnings.
>
> "The steep inflationary climb in the prices of building materials in the wake of the oil crisis, which had once been held certain to last for a long time and thus amply woven into the contract prices of most of the fiscal 1976 newbuilding deliveries, began to slacken rapidly in and after 1975. This made it possible for the seven to buy a large amount of the materials needed for these jobs at unexpectedly low prices.
>
> "All-out cost-saving efforts sustained by both their shipbuilding and non-shipbuilding branches through personnel cuts and work rationalization also helped the seven lower production costs appreciably.
>
> "The business climate surrounding non-shipbuilding activities began to take on a favorable trend." **

* Mitsubishi, IHI, Mitsui Zosen, Hitachi Zosen, Kawasaki, Sumitomo, and Sasebo.

** Zosen, July 1977. Underlining added.

Despite the fact that inaccurate cost estimating is currently generating windfall profits -- as the official at Kawasaki sums it up -- "cost estimating is now a big problem to Japanese builders." Their ability to predict future costs is much less than in earlier years.

(3) <u>Unpredicted Increases In Labor And Material Costs Have Affected Original Cost Estimates In Other Countries</u>

Examples of under and over cost estimating in Japan are cited above. There are many other examples in other shipbuilding countries where the cost of labor and material took an unexpected jump in 1973-74.

Perhaps a relevant example is that of the contract for the six Mark 10 frigates ordered by the Brazilian Navy from Vosper Thornycraft in the U.K. On the basis of designs prepared by Vosper Thornycraft, a contract was signed in September 1970 valued at about £ 100 million for six ships.

According to a recent article, "the contract provided for adjustment to cover increases in the costs of labour and materials and these, together with subsequent changes in the specification have resulted in the present value of the contract being about £ 150 million." *

* Shipbuilding & Marine Engineering International, Jan./Feb. 1977.

Another example is the 7800 GRT ferry, St. Columbia, ordered by British Rail from Aalborg Vaerft in Denmark. Original cost was estimated at £14 million but turned out to cost £19 million. *

(4) In The United States Shipbuilders Have Been Experiencing Great Difficulty In Accurately Estimating Costs -- For Ships Far Less Complex Than Naval Combatants

The relatively uncomplicated merchant shipbuilding programs in the United States have also resulted in shipyard overruns and losses, largely due to the yards' inability to project reasonable labor, material and overhead costs during the recent inflationary period. The numerous and continuing shipyard claims being made against the owners demonstrate the effort being made to recoup losses through arbitration or the courts.

Review of shipyard data for man-hours to complete relatively simple (i.e., compared with a navy combatant) merchant ships indicates a considerable variance between estimated and actual hours. The variances range from an underestimate of nine percent to 27 percent. And the ships involved are similar designs.

* Shipbuilding & Marine Engineering International, June 1977.

(5) The Financial Consequences Of Underestimated Final Costs Have Been Seriously Felt By U.S. Shipbuilders

Dun's Review reports in mid-1974 on the impact of underestimated costs as follows:

> "Avondale had a tough year in 1973, points out Leopoldo Clemente, an analyst for Merrill Lynch, Pierce, Fenner and Smith, because they underestimated their costs. But all of these contracts have since been renegotiated and are now profitable.
>
> "Another Merrill Lynch analyst is bearish on General Dynamics shipbuilding operation. The overall history of their Quincy (Massachusetts) yard has been terrible, he points out. Their cost estimates were way off and neither their customers nor the government are willing to renegotiate the contracts. So the company now has a claim against the government for $200 million." *

The 1975 Annual Report to Stockholders of Todd Shipyards provides further indication of the magnitude of the problem caused by low cost estimates, as well as other unanticipated events:

> In announcing the Government's decision to extend a 90 percent guarantee of a working capital loan, the Acting Secretary of Commerce on April 19, 1975 stated,
>
> > "A series of unfortunate, unpredictable, and uncontrollable events converged in late 1974 and early 1975 to cause Todd Shipyards unprecedented problems and a serious drain on

* Dun's Review, May 1974. Underlining added.

its working capital."

Events occurring in late 1974 were (a) an increase in labor and material costs at the Los Angeles and Seattle Divisions at a rate double that of the overall national average, (b) inability to obtain materials and unpredictable deliveries thereof, (c) failure of equipment resulting from deficient vendor quality control and failure to meet specifications, and (d) the general effect of the embargo by oil exporting nations. *

And National Steel reports it has:

"recorded a loss provision of $5,500,000 (after state and federal income taxes) in the 1976 first quarter to reflect estimated losses to be incurred in the completion of fixed price contracts covering ships presently scheduled for delivery in 1976, 1977 and 1978. **

The cost to complete these contracts was seriously underestimated -- thus the provision for loss on a fixed price contract.

* Todd Shipyards, Annual Report to Stockholders, 1975. Underlining added.

** Kaiser Industries, Shareholders News, first quarter 1976.

7. SHIPBUILDING IS NOT ALONE -- OTHER INDUSTRIES HAVE EXPERIENCED SIMILAR PROBLEMS IN MAKING ACCURATE COST ESTIMATES

It has not been demonstrated that the greater complexities of naval ship construction have resulted in proportionately larger overruns than those in most major civil and other military acquisition programs in the United States. The relatively uncomplicated merchant shipbuilding programs in the United States have also resulted in shipyard overruns and losses, largely due to the yards' inability to project reasonable labor, material and overhead costs during the recent inflationary period. The numerous and continuing shipyard claims being made against the owners demonstrate the effort being made to recoup losses through arbitration or the courts.

A General Accounting Office Report to Congress of January 18, 1977 on the subject of "Financial Status of Major Acquisitions as of June 30, 1976" indicates that 753 civil and military acquisitions checked had an original expected cost of $276 billion and are currently estimated to cost $452 billion or an average increase of 64 percent. This compares to 43 percent overrun for all the current Department of Navy programs. An analysis of those agencies with acquisition programs of $1 billion or greater indicates the following anticipated increases over the baseline estimates:

TABLE A.19

SELECTED GOVERNMENT DEPARTMENT OVERRUNS

Agency	Percent Increase
Appalachian Regional Commission	580
Department of Air Force	49
Department of Army	36
Department of Navy	43
Department of Army, Corps of Engineers	11
Bureau of Reclamation	72
National Park Service	27
Federal Highway Administration	160
Federal Railroad Administration	0
Urban Mass Transportation Administration	9
Energy Research and Development Administration	46
Environmental Protection Agency	37
National Aeronautics and Space Administration	24
Tennessee Valley Authority	36
Washington Metropolitan Area Transit Authority	121

The Report states:

> "Unanticipated development difficulties, inflation, faulty planning, poor management and poor estimating will increase the costs of major acquisitions. Cost growth cannot always be prevented or anticipated, particularly when a project is in development and production extends over long periods."

APPENDIX B

REVIEW OF RECENT CRITICISM AND STUDIES ON NAVY COST AND MANAGEMENT PROBLEMS

Appendix 2 of 5

Supports the final report entitled, <u>A Study Of Ship Acquisition Cost Estimating In The Naval Sea Systems Command</u>

Contract No. N00024-77-C-2013

INTERNATIONAL MARITIME ASSOCIATES, INC.
WASHINGTON, D.C.
OCTOBER 1977

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I. SUMMARY OF RECENT CRITICISM

The crux of the criticism leveled at the Navy and its "crisis of shipbuilding" are CONTRACTOR CLAIMS, SCHEDULE SLIPPAGE and COST GROWTH. These elements require the Congress to authorize and appropriate large additional amounts of public funds to complete previously authorized and funded programs. Under existing Ship Construction Navy (SCN) budget procedures, the Navy is required to full-fund all existing programs; therefore, when cost growth exceeds previously appropriated funds, for whatever reason, additional funds must be requested or programs cancelled to meet full-funding requirements. The need for additional funding, coupled with a long standing recognition of the fact that a crisis has existed, which together with an apparent lack of any highly visible progress towards solution, has severely damaged the credibility of the Navy. This has generated across-the-board criticism of all aspects of Navy ship acquisition. It should be pointed out that significant changes have been made in many areas such as contracting, claims settlement, product definition and in the management of GFE and GFI, which are designed to provide ships on time and at the most reasonably obtainable cost.

More specifically, criticism is found in all quarters, the focal point being the annual Congressional Authorization and Appropriation Hearings. Private shipbuilders, with their purported minimal or negative profits in Navy

contracts, have launched billion dollar claims packages with the attendant criticism and blame being directed at the Navy. The Executive Branch of the Government, mindful of its statutory responsibilities, has also been critical of the lack of progress and solution in the areas of claims settlement, claims prevention, program slippage and cost growth.

The criticism is so wide ranging and interrelated that any attempt to evaluate the criticism of "ship cost estimating" in isolation of other related criticism would appear unduly narrow. It should be noted that while cost estimating is one of the most often cited problems, and at times the term solely associated with cost growth and contractor claims, it is a term that is more often misapplied. Cost estimating defined as the technique or methodology for forecasting the future costs is not in itself a major cause of the criticism. Only if cost estimating is defined as the total acquisition process, including the management of the process, does the term apply. Moreover, that while many of the problems associated with cost growth and claims have been with the Navy for sometime, had it not been for the devastating effect of the inflation on the nation during 1973 and 1974, many of the problems and criticisms might not have surfaced or might well have been solved or coped with in the normal process. Therefore, in taking the broadest definition of cost estimating to include the total acquisition process, a tabulation of the most frequent criticisms together with their sources is set forth in Table B.1.

TABLE B.1

SUMMARY OF RECENT CRITICISM OF NAVY SHIPBUILDING

CRITICISM	CRITICS				
	Congress	Executive	Ship-builder	In House	Independent Studies*
Low Budget Estimates/Underfunding	X	X	X	X	X
Unrealistic Delivery Estimates	X	X			X
Program Instability	X	X	X	X	X
Unrealistic Shipbuilder Productivity Estimates	X	X			X
Excessive Government Changes	X	X			X
Inadequate Technical Definition	X	X	X		X
Faulty Specifications	X	X	X		X
Late and Faulty GFM/GFI	X	X	X	X	X
Excessive Government Management Requirements	X	X	X	X	X
Late Specification Changes	X		X	X	
Excessive Management Turnover	X	X	X		X
Excessive Management Layering	X	X	X	X	X
Excessive Claims	X	X	X	X	X
Inflexible Contracting Methods		X	X	X	X

* Comments regarding study criticism are set forth in Chapter III.

II. RECENT CRITICISM AND SOURCES

The expanded Navy Shipbuilding Programs that are currently in progress and which are encountering increasing delays in deliveries, large increases in cost growth and escalation for prior years, together with a mounting backlog of claims, has subjected the Navy to continuing review and critical analysis. While the Navy has been implementing revised contracting and management methods designed to remove these problems, widespread criticism continues. Specific corrective action is discussed herein and elsewhere in this report. This section will identify the current criticism and its sources. The data set forth herein was obtained from review of written materials and personal interviews with well informed individuals from Congressional, Executive, Industrial, and In-house Navy sectors.

1. LEGISLATIVE CRITICISM

(1) Congressional Hearings And Requests For Additional Funds Are A Focal Point Of Criticism

A significant point of focus with respect to criticism within the Congress is the request for additional funds to provide full funding for escalation and cost growth in prior-year shipbuilding programs.

This becomes an extremely critical issue since the Ship Construction Navy (SCN) Appropriation is funded under an "End Cost" concept whereby all costs to fully complete the program were to be budgeted in the particular program year. The process for requesting additional funds for prior year programs is contrary to the "End Cost" concept of budgeting which has been in effect since Fiscal Year 1961. Prior to that time, lacking the necessary funds the Navy had to either delay or defer the award of new ships until additional funds were available or cancel previously awarded ships to provide a source of necessary funding.

In the 1976 budget request for SCN, a total of $2.3 billion was requested to full-fund cost growth and escalation for prior year programs as shown below.

FY 76 REQUEST

Escalation on prior year Programs (Includes contract escalation, GFE inflation)	$1,149,800,000
Cost Growth (Includes $150 Million for Claims)	$1,119,500,000

Subsequent actions by the Congress resulted in a deferral of approximately $1.0 billion of the full funding requirements on the basis that such funds were not required to be obligated in FY 76. This

deferral is shown below.

FY 76 FULL FUNDING DEFERRAL

Escalation	-$729,500,000
Cost Growth	-$293,200,000*

* Includes $150,000,000 for Claims

- This full funding deferral action was a deviation from long standing full funding requirements for shipbuilding going back to 1957 when the Chairman of the Subcommittee on Defense Appropriations stated that the general prevailing practice of the Subcommittee was to provide funds at the outset for the total estimated cost of a given item so that the Congress and the public could clearly see and have a complete knowledge of the full dimensions and cost of any item or program when it is first presented for an appropriation.

- The Senate Committee on the Armed Services, in its acceptance of the FY 1976 deferral action, reaffirmed its support of the full funding concept for Navy ships and pointed out that a one year deviation from the full funding concept for FY 1975 and prior programs was made because of the uncertainties of shipbuilding programs and unusual economic conditions.

- The House Committee on Appropriations in the FY 1976 hearings indicated that it did not believe it prudent for the Congress to endorse or give credence to predicted annual rates of inflation in labor and materials by "locking" those rates into authorization acts. The Committee further indicated that in the future they intended to authorize only such funds for escalation in shipbuilding programs as were estimated to be obligated in the current fiscal year and the next following year.

- To further highlight the current intensity of the problem, it should be noted that only $50 million of the $2.3 billion full funding request for FY 1976 was for ship programs approved earlier than fiscal year 1970.

The request for full funding in FY 1977 was $1.6 billion which included the $1.0 billion deferred in the action cited previously.

FY 77 BUDGET REQUEST
($ in Millions)

	FY 76 Deferred	FY 77 New Rqmts.	Total
Escalation	$729.5	$360.0	$1,089.5
Cost Growth	$273.8	$259.9	$ 533.7*
		TOTAL	$1,623.2

* Included total of $320 Million for Claims

In the FY 78 request for full funding, the total amount was $566.1 million and did not include any additional funds for prior year escalation. Prior year unexpended escalation funds were available to offset some of the prior year cost growth.

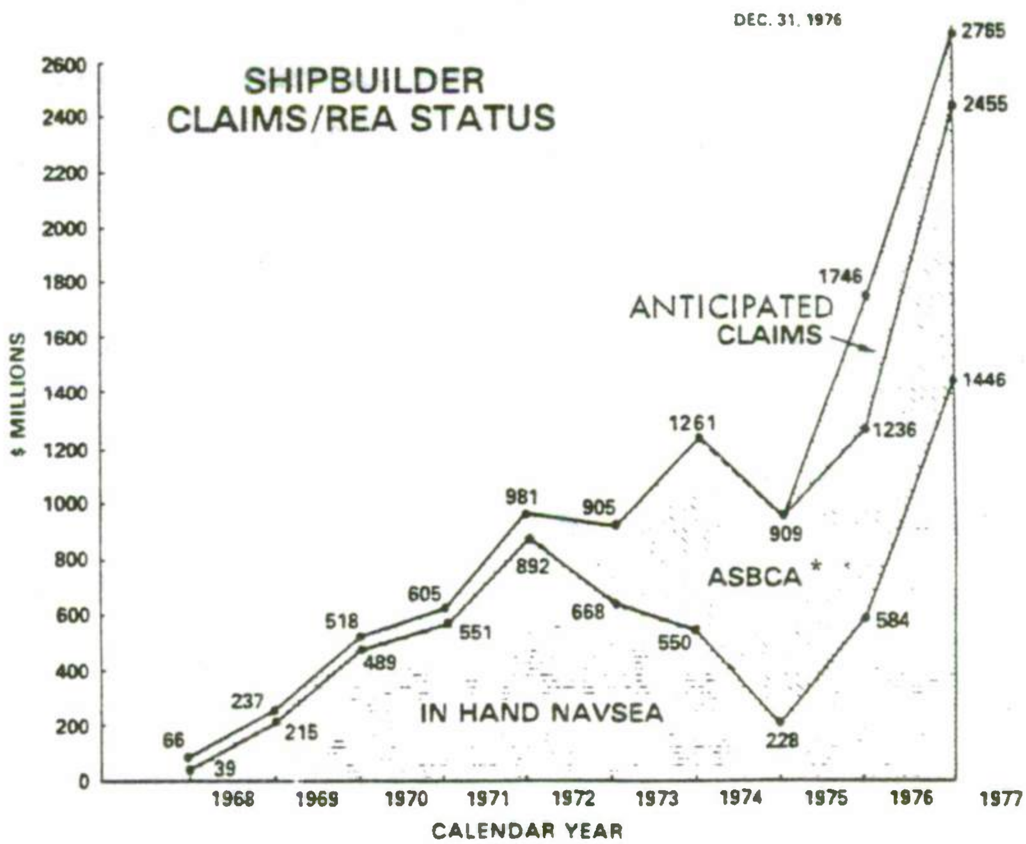
FY 78 BUDGET REQUEST
($ In Millions)

Escalation	
FY 75 and prior year program cost growth	$184.7
Funds for impending claims settlement	$370.0
Support for Claims analysis	$ 11.4
Total	$566.1

(2) A Major Point Of Criticism Within The Congress Is The Volatile Claims Situation

In March 1977, during the FY 78 Authorization Hearings, Senator John C. Stennis, Chairman of the Senate Committee on Armed Services stated in part that the existence of substantial claims against the government and their underlying causes represent one of the most serious problems facing the Navy and the Department of Defense. The current total of claims as reported to the Congress in March 1977 was $2,455,300,000 as of 31 December 1976. This was later modified to a total of $2,532,900,000 which resulted from a combination of adjustments downward due to settlement and increases due to additional claims received. Figure B.1 summarizes the overall claim status as discussed above.

Figure B.1



Source: HAC Report (3/22/77)

* Armed Services Board of Contract Appeals (ASBCA)

- To the Congress such claims represent mismanagement on the part of the contractor as well as the Navy.

- Any attempt at settlement that does not follow the established safeguards listed below is viewed by some as a government "bailout" of the shipbuilders who had been unable to build and deliver ships to the Navy on time and for agreed upon costs:

  - A thorough review of legal entitlement, extensive fact finding and analysis of the claim by the Government.

  - Appropriate certifications by senior company officials that the claim and all supporting data provided to the government are current, complete and accurate.

  - FY 77 DOD Appropriation Act specified that "none of the funds appropriated... may be used to pay any claim... unless such claim has been thoroughly examined and evaluated."

- Navy culpability in the claims area is generally alleged to be due to incomplete or erroneous design packages which result in numerous changes during the construction period and form the basis for future claims especially in the delay and disruption category.

(3) <u>Navy Continues To Submit Requests For Funding From Congress For The Construction Of Ships That Have Not Been Completely Designed</u>

- Members view the lack of a Budget Quality estimate as indicators of insufficient design, production or cost information.

- CGN 40 and AS 39 in FY 1972, FFG-7 in FY 73, the TRIDENT Submarine in FY 74; the DDG-47 in FY 77 and CSGN strike cruiser in FY 77 and 78 are cited as examples of ships for which the Navy has requested funds based on less than budget quality (Class "C") estimates.

- Cost growth and schedule slippage are seen as by-products of poor budget estimates.

(4) <u>The Apparent Inability To Estimate Accurate Delivery Dates Raises Additional Criticism</u>

The Congress is also highly critical of the Navy's apparent inability to estimate accurate delivery dates for the ships authorized. Congress has concluded that this is due primarily to an over optimistic estimate of a shipbuilder's productive capacity by both the Navy and the shipbuilder. A survey recently completed by the Navy indicated that of the ships awarded in the past ten years, contract delivery dates have in general not been met.

- As of April 1976, there were 91 new construction ships under contract with ten shipbuilders. 59 of those were under construction, 27 out of the 91 ships were maintaining contractual schedules. The remaining 64 ships had identified slippages of original contract schedules from three to 52 months, with further slippage of some schedules anticipated.

- While the Navy has informed the Congress that current delivery estimates reflect updated construction periods based on known projected longer lead times for procuring vendor supplied materials, as well as updated shipyard production capacity estimates, there remains a high degree of skepticism regarding delivery dates.

(5) Another Point Of Continuing Criticism Concerns Personnel Turnover

Most of the criticism in this area is directed at the policy-making and top decision-making levels of management. From the Congressional point of view, this lack of personnel stability within those areas of the DOD that have cognizance in shipbuilding matters has resulted in frequent and continual perturbation in the shipbuilding program. Whatever the primary motivation, out of this criticism has come the mandate for the stable five year shipbuilding program.

(6) Disposition Of Legislative Criticism

With the backlog of unsettled claims as the focal point of Congressional criticism of the naval shipbuilding programs, the Navy has approached the solution to the claims problem in a positive and forthright manner. For the short term, they have established the Navy Claims Settlement Board with a goal of settling the Newport News and Electric Boat claims by the end of 1977. For the long term, they are working to reduce, where feasible, the basic causes of increased costs which the Navy views as the underlying cause of claims.

In the area of claims settlement, the Armed Service Committee of the House in their report of 21 June 1977, noted that of $2.4 billion in claims outstanding, approximately $1.0 billion was under litigation

before the Armed Services Board of Contract Appeals or in the Federal Courts. The Committee further noted that:

> "The Navy is making a commendable effort to negotiate claim settlement on the basis of legal entitlement and the proper amount of price increases due to the contractors. While there is pressure from some sources to make quick and expedient settlements, the Navy must comply with the requirement of the Department of Defense Appropriation Act of 1977 that each claim be thoroughly examined and evaluated and its validity certified to the Congress prior to payment...."

The long term claims solution effort is in the direction of claims prevention by eliminating the basic causes of claims. The Navy effort is specifically aimed at the elimination of such "cost drivers" as defective specifications, defective plans and drawings, late or defective Government Furnished Equipment and better control of changes. Positive efforts to date have included new contract provisions providing for more realistic escalation payments, utilization of cost type contracts for lead ships, greater contractor participation in the ship design process and greater time lapse between lead and follow ship contracts. This study concurs in these steps and discusses in detail elsewhere in this report some of the causes and impact of poor budget estimates.

2. TOP LEVEL EXECUTIVE BRANCH CRITICISM

Within the Executive Branch of the Government there has been a continuing awareness of the difficulties involved in the solution of problems besetting the Navy's shipbuilding programs. Secretary of Defense Melvin Laird, in one of his first appearances before the Congress in March 1969 spoke of the urgent need for a comprehensive review of the Navy shipbuilding program. He cited an estimated deficit of $600-700 million of funds to complete ships then in ongoing building programs. He spoke of large cost overruns, of multi-million dollar claims, of programmed ship cancellations. He said at that time that we must begin to get the program under control.

The major criticism today evolves around an apparent lack of progress in solving the shipbuilding problems. This is exacerbated by Congressional pressures brought about by the seemingly endless requirement to full-fund prior year programs. This coupled with the adversarial relationships existing between the Navy and shipbuilders involving an increasing spiral of claims now totaling some $2.5 billion outstanding for Navy ships currently authorized and ship delivery slippages of from three months to five years highlights a highly volatile situation.

However, it should be noted that with respect to requests for additional funds for prior year programs, the FY 1978 budget request continued the downward trend from the high of 1976.

(1) Criticism Within The Department Of Defense

Deputy Secretary of Defense Clements indicated that failure to correct the problems of cost overruns, program slippage and contractor claims has brought about a situation where the President and the Congress are losing confidence in the Navy. The Secretary of Defense has acknowledged to the Congress that "the ultimate responsibility for approval, management, and program execution lies with the Secretary of Defense." He advised the Navy that they are jeopardizing current and future programs by their failure to resolve the grave contractual problems that currently exist.

(2) Specific Criticisim Within The Executive Branch Is Similiar To That Expressed In The Congress

Some of the more critical condusions are listed below.

- Combatant surface ships were being included in the Navy budget with incomplete plans, specifications and analysis
- Slippages due in part to unrealistic delivery dates
- Lengthy change order approval process
- Unrefined cost estimates are submitted as budget class estimates
- Instability in yearly shipbuilding programs impede shipyard modernization
- Navy decision making process is too long and extensive
- Adversarial relationships prevalent mainly in nuclear area with some in conventional yards

(3) Disposition Of Executive Branch Criticism

Criticism within the Executive Branch of the Government, as in other areas, is directed at mounting cost growth, increasing claims and continued slippages in ship deliveries. While solutions with respect to claims that are equitable to both the shipbuilder and the Government and are in accordance with the law are time consuming, the apparent lack of any major progress toward their settlement and their implied impact on the business of providing naval ships at a planned cost and on schedule is still the crux of the criticism.

3. IN-HOUSE NAVY CRITICISM

In-house Navy criticism can be grouped in two general categories: shipbuilding industry shortcomings and in-house management procedures. Superimposed on these two general groupings is the overall problem of inflation and its impact on cost and schedule. All concerned readily concede to a gross misestimate with respect to inflation. Necessary adjustments are being incorporated in all new contracts. In current contracts, adjustments are being made on a case-by-case basis where allowable under existing legal bounds.

(1) <u>A Majority Of The In-House Criticism Is Directed At The Shipbuilding Industry</u>

Even with inflation shortfalls excepted, the position taken is that the shipbuilders, at the time of contract signing, have sufficient knowledge and data at their disposal to permit the signing of an equitable and feasible contract which provides for the construction and delivery of ships within cost and on schedule. This position is taken assuming that equitable cost and schedule adjustment will be made for Navy directed changes and Navy responsible design deficiencies. More specifically, criticism is directed towards industry's "over-optimism" as to attainable production capacity and its attendant labor requirements.

- Shortfalls in estimating labor availability, skill mix, buildup rate and turnover rates have been cited as primary slippage factors. Accountability for labor and productivity estimates is viewed as within the purview of industry and, therefore, is properly a business risk not attributable to government action or inaction.

- Claims and their accompanying adversarial atmosphere are a constant impediment from both a funding and manpower requirements viewpoint. The Navy insists that industry's claims are, in general, exaggerated and unsupported, thus necessitating extensive fact finding, probing and data development to provide a basis for an equitable claim evaluation. The claims situation is further irritated by late submissions, revisions and resubmissions, all of which give rise to a questioning of the credibility of the shipbuilding industry.

(2) Program Instability Brought About By What Appears To Be Budget Pressures Generate The Most Frequent Criticism From Management Personnel

These pressures drive what are often short deadline trade-off studies which impact long-lead time procurement and ship delivery schedules. Pressured deviations from established design and cost estimate phasing are also seen as self-defeating procedures. The constant probing for "excess" management reserves in an attempt to keep estimates reasonable is viewed as a potential for cost overrun. In the post-budget phase, such actions as late surfacing changes in reliability and maintainability requirements and GFE improvement programs are voiced as potential overrun and slippage factors. These together with the annual budget-driven program stretch-out or contractions in the case of new ship designs are also seen as major cost and schedule inhibitors.

4. INDUSTRY CRITICISM

The annual Congressional hearings are again the focal point and forum for criticism of the Navy shipbuilding programs. In 1972 and again in 1974, the shipbuilding industry, represented by some of the top executives of the major shipbuilding yards as well as the President of the Shipbuilders Council of America, in extensive hearings before the Seapower Subcommittee of the Committee on Armed Forces, House of Representatives, had a long list of

complaints and problems concerning the Navy's shipbuilding programs.

(1) Industry Criticism Covers A Broad Spectrum Of Problems

Criticism by representatives of the shipbuilding community has ranged from problems concerning claims to the establishment of a stable program. Some of the most frequently heard criticisms were as noted below.

- Lack of a firm long range shipbuilding program
- Lack of timeliness in settlement of change order cost and claims
- Pattern of diminishing profits on Navy contracts
- Excessive government supervision and interference
- Numerous change orders
- Accuracy of Navy drawings and specifications
- Critical material priorities
- Inflation payments
- Adversarial and acrimonious Navy-Shipbuilder business relationship

(2) Many Corrective Actions Recommended In 1974 Have Not Been Taken

A review of the industry position with regard to business relationships in Navy shipbuilding indicated that a majority of the points set forth in the 1974 hearings were still present as late as May 1977.

A major point of criticism is still the diminishing profit picture in Navy shipbuilding contracts. The industry points out that by Navy estimates as set forth by the DEPSECDEF before the Subcommittee on Priorities and Economics in Government of the Joint Committee on June 25, 1976, that for 11 contracts then in force, involving 70 ships and a cost of $8.65 billion, the shipbuilders would incur a loss of nearly $500 million (loss of 5.8 percent). Industry points out that those 70 ships represent approximately two-thirds of the value of all major Naval vessels under construction and reflect a 14-year time span of performance from commencement of the first ship (1968) until scheduled delivery of the last (1981). Therefore, for Naval shipbuilding contracts, industry sees this not as a transient phenomenon of minimal to negative realized profits, but as a malaise extending well over a decade.

Industry also notes that DOD policies, procurement regulations and reporting requirements result in excessive management and create an adversarial business relationship with the Government. They continue to highlight the cost implications of late GFI and GFM, as well as erroneous and incomplete GFI. With respect to ship definition, they allege errors and inconsistencies in primary specifications coupled with a need to simplify primary and subordinate specifications.

(3) Views Expressed By The President Of The Shipbuilders Council Of America

The position of industry as expressed by the President of the Shipbuilders Council of America (SCA) in a letter to the Deputy Secretary of Defense, dated 20 October 1976, reaffirmed that with respect to the problems highlighted in the 1974 Seapower hearings - "Each recommendation is pertinent to a problem area we believed - and still believe - to be a significantly contributing cause of the lengthy disputes which have characterized dealings in the past several years and which are symptomized by the level of outstanding claims. We believed then - and believe now - that unless these problem areas are fully addressed and appropriately reconciled, there is a high probability of repetitive disputes culminating in another round of claims." A listing of 39 recommendations was prepared in connection the SCA Ad Hoc Committee report - "A Discussion of Navy Shipbuilding Industry Business Relationships".

The Shipbuilders Council asserts that of 39 recommendations made in the hearings of 1974, only two have been accepted. One with respect to the method of progress payment which it now regards as alleviating the problems of cash flow probably to the maximum expectable extent, and the other with respect to an examination of government or-

ganizational structure bearing on ship procurement and production where it previously rated all sorts of "examinations" but no clear benefit, but now grant that the apparent attitude approach of the incumbent COMNAVSEA shows promise of improvement in relationships. Of the remaining 37 recommendations, as of 2 May 1977, they perceive partial accommodation of 10 and no sign of affirmative action on the remaining 27. These recommendations with appropriate Navy and industry comments are attached as Exibit B.1 for information.

It should be pointed out that these Ad Hoc Committee recommendations represent the combined views of all its members, even though some are working more closely with Navy requirements than others and, in several instances, partial or total accommodation has been reached. Hence, when SCA indicates that Navy has not accommodated most of its recommendations, while technically correct with respect to the entire council membership, it does not represent the true extent of Navy action. A typical example is compliance with DOD INST. 7000.2, whereas three yards have already qualified for a management reporting system and some other yards are in the process of complying. In fact, during shipyard visits it was learned that some shipbuilders see 7000.2 compliance as being to their advantage from a management viewpoint.

In sum, it should be pointed out that only three of the 39 SCA recommendations apply indirectly to NAVSEA estimating and budgeting

functions and are:

- Improve accuracy of definition of ship to be built - which SCA agrees the government is trying to improve.

- Improve the accuracy of forecasting probable costs - SCA points out that this contemplates far more than improving quality of inflation forecasts. Probably, recent study efforts to find out "what's wrong with our estimating system" is a far more significant effort to improve accuracy.

- Provide reasonably for known and unknown contingencies - SCA views "balance of risk" as interpreted under existing regulations as balancing risk at Navy - 0, builder 100 - pending "claim" and claim resolution.

(4) Disposition Of Industry Criticism

The SCA recommendations represent a compendium of all the shipbuilders' views without giving emphasis or priority to the more critical items. Navy planning, contracting and administrative problems are emphasized with only limited criticism of Navy estimating and budgeting methods. Agreements with all the recommendations would not be acceptable to Congress or follow recognized contracting practices. Corrective measures to the extent feasible will improve Navy - shipbuilder relationships; however, the contracts should be fair to both parties while at the same time acknowledging that every contract entails some risk for both parties. It is within this context that the Navy under the

direction of the Assistant Secretary of the Navy (Installations and Logistics) ASN(I&L) is currently addressing many of the problems raised in the Ad Hoc report with a view towards improving the Navy-industry management practices and business relationships,and with the goal of avoiding or at least limiting future claims. This effort will undoubtedly serve as a clearing house for Navy - Shipbuilding Industry problems such as those Ad Hoc Committee recommendations still listed as partially or not accommodated.

III. REVIEW OF PAST STUDIES RELATING TO COST ESTIMATING AND SHIPBUILDING

Rising costs and cost growth in weapon system acquisition have been the stimulus for numerous studies from both within and without the government over the years. These studies have been comprehensive and in some cases far-reaching, covering in broad perspective such matters as management, budgeting, policy, procedures, and organization. Cost estimating was analyzed in varying detail, but only as part of the overall Department of Defense functions, including its acquisition process. Recognizing that there have been literally dozens of recommendations regarding cost estimating, this study will identify the more important estimating recommendations and assess their practicality and the effectiveness of implementation on cost estimates in shipbuilding. It will also identify the recommendations already implemented in whole or in part, as well as include the independent findings believed necessary to improve estimating outputs.

1. A LARGE NUMBER OF STUDIES ON ACQUISITION PROCEDURES HAVE BEEN DEVELOPED DURING PAST SEVERAL YEARS

A total of 20 significant studies have been reviewed and summarized. The earliest study was developed in 1939 with the latest being issued in 1977. Most of the studies cover the past ten years during which period the serious cost increases and overruns have taken place. Summaries of each of the 20 studies are in Exhibit B.2, with emphasis on those findings and recommendations

pertinent to the estimating process. The studies in chronological order are:

Date	Title	Source
9-21-39	Cost of Naval Ships	Bureau of S and A to SECNAV
12-1-67	New Construction Cost of Major Warships	Chief, Naval Operations (Holloway)
1-30-69	An Evaluation of the Effec tiveness of the Ship Procure-ment Study	NAVSHIPS Procurement Review Group (Sanders-Scanlon)
2-10-69	Study of Economic Factors Applicable to Shipbuilding	Center for Naval Analyses
4-1-69	SCN Pricing & Cost Control Study	Chief, Naval Material
4-10-69	Survey of Government and Industry Cost Estimating and Cost Control	Booz-Allen
7-1-70	Blue Ribbon Defense Panel	President and Secretary of Defense
9-5-70	Review of Estimating Techniques within DOD	ASPR Pricing Subcommittee
9-21-70	Organizational Problems in SCN Procurement Systems	Center for Naval Analyses
6-10-71	Command Inspection of Naval Ship Systems Command Headquarters	CNM
7-72	Shipbuilding and Conversion Improvement Program (SCIP)	CNO
7-17-72	Acquisition of Major Weapon Systems - Department of Defense	GAO
7-24-72	Theory and Practice of Cost Estimating for Major Acquisitions in DOD	GAO
12-72	Report of the Commission on Government Procurement	Industry - Government (Public Law 91-129)

(continued)

Date	Title	Source
3-73	Study of Cost Escalation	DOD
10-22-74	Discussion of Navy Shipbuilding Industry Business Relationships	Shipbuilders Council of America
1-75	Report of the Navy-Marine Corps Acquisition Review Committee (NMARC)	SECNAV
4-11-75	Financial Management Planning Group Inflation Study	ASN
9-30-75	Report of the Acquisition Advisory Group to Deputy Secretary of Defense	Deputy Secretary of Defense
1-18-77	Financial Status of Major Acquisitions as of June 30, 1976 (Covering all Major, Fully or Partially Government Funded Programs)	GAO

(1) These Studies Relate Directly or Indirectly to Estimating Procedures

All the aforelisted acquisition studies and reports relate directly or indirectly to estimating. A commonality in selected phases of the process runs through each study, even though greater emphasis may be

placed on organization, management and other aspects of acquisition. Many of the recommendations and suggestions have been implemented, while others for various reasons have either not been implemented or only implemented in part.

(2) <u>The Majority Of Studies Have Been Undertaken By Components Of Department Of Defense, Its Consultants And the GAO</u>

The majority of studies have been undertaken by components of the Department of Defense, supplemented by consultants. The GAO has participated heavily in government procurement studies. A great perception of the overall problem is evident, although only limited exploration of the detailed estimating process has been undertaken. Many cost drivers have been identified and a few of the reports recognize the unpredictable pitfalls facing the estimators which can only be reduced by an adequate estimating base and sufficient time to perform a credible estimate.

(3) <u>Only A Limited Number Of Studies Have Had Industry Participation</u>

A few of the studies have been developed with the participation of industry such as the Commission on Government Procurement Report (1972), Blue Ribbon Defense Panel Report (1970) and the Navy and Marine Corps Acquisition Review Committee Report (1975). The Commission on Government Procurement covers Government-wide acquisition programs. Its basic emphasis is on the entire process including research and development, major systems, commercial products, engineering services, Federal Grant programs, liabilities, patents and administration.

The report states this rationalization on estimating:

> "Because of the repeated pattern of major cost increases in system acquisitions, many people have concluded that there is need for better cost estimating and better risk analysis. However, improved estimating techniques can bring only relatively small improvements. About 15 percent of cost growth in major programs during the 1960's can be attributed to the inherent imprecision of present cost estimating procedures. Better cost control will come only if fundamental changes are made in the way systems are refined and chosen early in the acquisition process; these steps largely determine ultimate cost and performance."

The Blue Ribbon Defense Panel Report is heavily oriented in DOD organizations, but it has a few pertinent findings on cost estimating and contracting, the highlights of which are:

- The accuracy of cost estimates for acquisition programs has been widely overrated. It should be axiomatic that one cannot place a price on any program containing any unknowns.

- Contractor eagerness to sell long-term acquisition programs influences low-side cost estimates.

- Contracting policies and procedures have a tendency to support the level of proposed cost estimates.

- Competitive pressures of concept/formulation/contract definition have led to over-optimistic cost estimates for acquisition and not permitted a hard look at inherent pricing uncertainties. Parametric cost estimating techniques offer the potential for improved planning of cost factors.

- The lack of cost data base information for prior programs limits the accuracy of cost predictions for current ones.

- Original cost estimates should be considered only as baselines and should be revised and updated across the system or equipment life cycle.

The Navy and Marine Corps Acquisition Review Committee Report (1975) is the most complete study of those recently undertaken. There were a total of 254 recommendations of which 26 had some direct or indirect application to the estimating process. The Report states:

> "Existing Navy cost estimating staffs are professional, competent and produce better estimates than they are generally given credit for. However, they are understaffed in relation to their workload and are frequently required to develop estimates to a very tight schedule on the basis of very limited data. To ensure the integrity, completeness, and currency of cost estimates, it is necessary that the cost estimating groups in the Naval Sea Systems Command be given adequate manpower and improved information and that the cost data be given to the NSARC."

(4) <u>The Shipbuilders Council Paper Has Only Limited Criticism of Navy Estimating Procedures</u>

An important paper developed by the shipbuilding industry was issued on October 22, 1974 by the Shipbuilders Council of America. It was titled "A Discussion of Navy - Shipbuilding Industry Business Relationships" which summarized the testimony presented before the Seapower Committee of the House Committee on Armed Services during July and August of 1974. It delineates the collective views of the shipbuilders having Navy contracts. The broad spectra of problem areas are:

- Improving overall buyer/seller relationship
- Definition of ship to be built
- Realism in pricing and scheduling
- Availability of Government Furnished Information and Material
- Recognition of cost impact of delays
- Relationships of change orders
- Proliferation of management information reporting systems
- Reasonableness of quality assurance requirements
- Role of Defense Contract Audit Agency
- Needless monitoring of contractor purchasing actions.

The main thrust is in contracting and contract administration. Hence, only a few of the broad SCA recommendations apply directly to NAVSEA estimating functions. These are:

- Improve accuracy of definition of ship to be built
- Improve accuracy of forecasting probable costs
- Provide reasonably for known and unknown contingencies
- Realism in scheduling

(5) The Studies Indicate A Commonality Of Importance In Navy Estimating Factors

A total of 14 estimating factors were selected, the definitions of which are summarized in Table B.2. The commonality of the various acquisition study recommendations and areas of greatest concern to those involved in developing the many findings are best demonstrated through a matrix of the studies as shown in Table B.3, Summary of Major Acquisition Studies Recommendations Related Directly or Indirectly To The Estimating Process. A brief overview of the Table readily identifies aspects of the estimating process that were of greatest concern to those involved in developing the findings. For example, there was considerable agreement on the need for a clear "Technical Definition" of the system to be estimated. Heavy emphasis was also placed on the need for a complete "Data Bank" as well as the "Economics of Shipbuilding," which are very basic tools in the estimating process.

TABLE B.2

ESTIMATING FACTOR DEFINITIONS

Technical Definition	-	sufficient definition of system or ship to develop class of estimate desired
Data Bank	-	estimating information for use as cost base, i.e., return costs, bid data, vendor data, etc.
Staff Resources	-	quality and quantity of staff necessary to produce creditable estimates (and costing function) on a timely basis
Staff Training	-	staff education, updating skills, special assignments, etc.
Reserves	-	estimating allowances, margins, change orders, contingencies, etc.
Economics of Shipbuilding	-	escalation, marketplace, BLS indices, profit considerations, shortages of key material, shipyard interest, etc.
Documentation	-	history of estimates, development assumptions, data sources, traceability, etc.
Review and Authentication	-	estimate review and authentication by higher authority
Realistic Construction Schedules	-	realism of proposed construction time and ability of contractors to meet contract schedule
Related Costing Functions	-	performance of cost related functions, i.e., life-cycle cost, should-cost, technical analysis review, etc.
Centralized Estimating	-	central estimating staff in each command vs. split responsibility throughout
Classification of Estimates	-	grading of the quality of the estimates commensurate with requirement
Budgeting Process	-	modify estimates to reflect program and ship definition changes, reduction of budgets below estimates, influences other than estimating
Cost Management Control	-	follow-up on cost, whether cost on target, etc.

TABLE B.3

SUMMARY OF MAJOR ACQUISITION STUDY RECOMMENDATIONS
RELATED DIRECTLY OR INDIRECTLY TO THE ESTIMATING PROCESS

		Estimating Considerations													
Major Acquisition Study Title Source Of Study	Date of Study	Technical Definition	Data Banks	Staff Resources	Staff Training	Reserves	Economics of Shipbuilding	Documentation	Review and Authentication	Realistic Construction Schd.	Related Costing Functions	Centralized Estimating	Classification of Estimates	Budgeting Process	Cost Management Control
Cost of Naval Ships (Bureau Sand A to SECNAV)	09-21-39	X	X				X								X
New Construction Cost of Major Warship (Chief, Naval Operations - Holloway)	12-01-67	X	X	X		X				X	X	X		X	X
Evaluation of the Effectiveness of Ship Procurement Study (NAVSHIPS Procurement Review Group - Scanlon)	01-30-69	X	X			X	X			X				X	X
Study of Economic Factors Applicable to Shipbuilding (Center of Naval Analysis)	02-10-69	X	X	X			X								
Survey of Government and Industry Estimating and Cost Control (Booz - Allen)	04-10-69	X	X	X					X						
SCN Pricing and Control Study (Chief, Naval Material)	04-69	X	X	X			X			X			X	X	
Blue Ribbon Defense Panel (President and Secretary of Defense)	07-31-70		X	X	X		X						X	X	
Review of Estimating Techniques Within DOD (ASPR Pricing Subcommittee)	09-05-70	X	X			X	X		X				X		X
Organizational Problems in SCN Procurement Systems (Center for Naval Analysis)	09-21-70		X												
Command Inspection of Naval Ship Systems Command Headquarters (Chief, Naval Material)	05-10-71				X	X						X	X		X
Shipbuilding and Conversion Improvement Program (SCIP) (Chief, Naval Operations)	07-72	X				X	X								
Acquisition of Major Weapon Systems - DOD (GAO)	07-17-72	X	X				X	X	X						
Theory and Practice of Cost Estimating For Major Acquisitions in DOD (GAO)	07-24-72		X				X	X	X						
Report of the Commission on Government Procurement (Industry - Govt. Public Law 91-129)	12-72	X								X					
Study of Cost Escalation (DOD)	03-73	X	X				X			X					
Discussion of Navy Shipbuilding Industry Business Relationships (Shipbuilders Council of America)	10-22-74	X	X				X								
Report of the Navy-Marine Corp Acquisition Review Committee (NMARC) (SECNAV)	01-75	X	X	X		X	X	X	X	X	X	X	X	X	X
Financial Inflation Management Planning Group Study (ASI4)	04-11-75		X			X								X	X
Report of the Acquisition Advisory Group to Secretary of Defense (Deputy Secretary of Defense)	09-30-75					X	X	X						X	X
Financial Status of Major Acquisitions as of June 30, 1976 (GAO)	01-18-77		X			X			X					X	
IMA RECOMMENDATION CATEGORIES	10-77	X	X	X	X	X	X	X	X	X	X	X	X	X	X

NOTE: (1) Those marked X are of special significance in the estimating process

Many findings, for example those in the Bureau of Supplies and Accounts "Cost of Naval Ships" study completed in 1939, are essentially valid today. While some of the recommendations in each study have been implemented, particularly those which can be accomplished at the operating level, many recommendations requiring significant changes in the acquisition process at higher management levels are more difficult. For example, adequate definitions of requirements and sufficient time allowed for estimating become shortchanged during phases of fluid planning and programming. These are not abnormal conditions, but at least should be absolutely minimized.

It is also interesting that several reports recognize the vagaries of the estimating process, and further indicate that estimating is not always the cause of overruns. The GAO Report of January 18, 1977 on Financial Status of Major Acquisitions as of June 30, 1976 (covering fully or partially Government funded major programs) indicates that an average of only 6.0 percent of the $150.9 billion overrun of 201 civil and defense acquisition programs with total original value of $249.6 billion is attributed to estimating. The balance is due to quantity changes, engineering, support, schedules, economic changes, and sundry such as environmental costs.

2. THE NAVY IS CONTINUING ITS EFFORTS TO RESOLVE THE ISSUES

A study group in the Office of the Assistant Secretary of the Navy (Installations and Logistics), ASN (I&L) has been established and with the assistance of a private contractor is currently addressing all the problems brought forth by the U.S. shipbuilding industry. The purpose of the study is to improve the Navy-industry management practices and business relationships, with the goal of avoiding or at least limiting future claims.

The initial phase of this Navy study will document the various views and problems of the industry already indicated in the many past studies relating to Navy-industry acquisition problems. The study group will also review and document the views of the Navy on what has been done, what is being done and what could be accomplished to improve the general business environment. After completion of the preliminary findings, a series of meetings are planned with the industry in an endeavor to resolve the many controversial issues.

3. MANY OF THE STUDY RECOMMENDATIONS HAVE BEEN IMPLEMENTED IN WHOLE OR PART AND CERTAIN IMPROVEMENTS ARE WARRANTED

Each of the 14 estimating factors listed in Table B.2 are analyzed and discussed in terms of the past study recommendations. Each analysis includes a brief definition of the factor and a discussion of its importance and practicality in the estimating process. Finally, conclusions are offered indicating to what degree the present estimating practices follow the more important study recommendations and what improvements if any, are believed necessary. These individual analyses of each estimating factor are included in this appendix.

Highlights of the conclusions on each estimating factor are offered:

Technical Definition - A sufficient definition of the system or ship should be required to maximize the quality of the estimate.

Data Bank - A continuing system of updating and upgrading the estimating data bank should be developed.

Staff Resources - Additional staffing with experienced personnel is required to meet the many estimating, budgeting and analysis requirements.

Staff Training - An excellent training program exists which should be supplemented with additional on-site field assignments for which sufficient funds should be provided.

Reserves - With unpredictable cost trends continuing, sufficient margins and reserves should be provided. This is especially true where less than Class "C" estimates are provided.

Economics of Industry - Acquisition of current industry economic information including that from shipyards, SupShips and Navy Auditors should be accelerated.

Documentation - This is being currently required in NAVSEA; however, it is not always being accomplished and the importance of developing and maintaining records to cover each phase of the weapon system and GFM estimating process cannot be overemphasized.

Review and Authentication — Adequate procedures to cover program estimates are established and no further action is required. However, higher level reviews of budget estimates are lacking and should be established.

Realistic Construction Schedules - Due to the importance of developing realistic construction award and completion schedules, improvements in predicting correct schedules are required. Failing this, funding margins should be provided for contingencies.

Related Costing Functions - Compliance with existing directives is not being met due to time and staff limitations. This condition may be improved by assignment of selective cost related functions to non-cost estimating groups or by necessary staff increases within NAVSEA 01G.

Centralized Estimating - This responsibility within NAVSEA and the delegation of SEA 01G as the focal point for all estimates has been complied with.

Classification of Estimates - A estimate classification system has been established since 1969 and is in use but needs more stringent criteria for budget quality estimates.

Budget Process - Despite the complications and policies of developing acquisition programs, the budgeting process, as a key element, must reflect professional estimates within which the programs may be successfully completed with a minimum risk of claims or budget overruns.

Cost Management Control - There is no continuing flow of program cost management control information into NAVSEA 01G. This is developed on an ad hoc basis whenever considered necessary in preparing estimates.

1. TECHNICAL DEFINITION

This relates to sufficient definition and details of system or ship to develop class of estimate desired.

Discussion

This is one of the three most important estimating factors, together with "Data Bank" and "Economics of Industry". It has been cited in the majority of study findings and its adverse impact on credible budget estimating continues.

Solution of the problem is inherently hampered by the PPB System; the rapid changing of ship programs in the POM and Budget brought about by late or changed decisions on what the Navy Program is to be; and stopping design development when a design is slipped or dropped from a program.

Review of the ship cost classification system , separately discussed in this appendix, has highlighted the fact that new and repeat ship programs frequently go to budget with less than Budget Quality, Class "C" estimates. The lack of firm definitized characteristics and inadequate ship definition are two of the major impediments to budget quality estimating.

Some previous attempts by NAVSEA to bring about improvement have not been successful, namely:

- Budget for a separate contingency factor for less than Class "C" estimates.

- Have OPNAV initiate the POM/BUDGET process in a timely manner as required in existing instructions.

Conclusion

It is axiomatic that unless the ship or systems are adequately defined and scoped, the best cost estimating system cannot properly develop costs.

A dedicated effort within Navy, at all cognizant echelons, must be made to assure a sufficient definition of the system or ship to maximize quality of the estimate. Where, in the realities of planning and budgeting, it becomes necessary to rapidly change programs and a less than Class "C" estimate may only be produced,the budget should include a separate contingency factor.

2. DATA BANK

This relates to comprehensive central cost estimating information for use as a cost base, such as returned shipyard costs, detailed bid cost breakdowns, vendor data, priced purchase orders, etc.

Discussion

This is also a primary estimating factor and was cited in most of the studies. A commercial shipyard in the preparation of a "will-cost" estimate has the following information available:

- Bidding specifications
- Contract plans
- Hundreds of vendor quotations for equipment described in specifications
- System sketches prepared from contract plans
- Ship weight breakdown by job accounts
- Manpower requirements by division
- Returned labor man-hours by job accounts
- Current and projected labor rates
- Current and projected overhead rates

Vendor material and equipment quotations and returned labor man-hour accounts and material costs are of prime importance. While NAVSEA initiated the process of obtaining vendor quotations several years ago, a review of the estimating techniques indicate the data bank needs updating and upgrading.

While realizing the delay factor and the interweaving of claim costs, continued emphasis on returned costs should be made and the data analyzed and converted to usable form to replace dependency on former bids and in-house estimates.

Some of the bid data available to NAVSEA is in insufficient detail to undertake meaningfull trade-off studies or to permit unit estimating. In addition, discussions with SEA 01G indicate occasional difficulties in consistently obtaining sufficient detailed contractors' cost data through the Contracts Directorate and Program Managers. This detailed cost information is a vital tool in the development of credible estimctes and Contract Cost Analyses.

Conclusion

NAVSEA should develop a continuing system of updating and upgrading its data bank through the use of current returned costs and other data which should be computerized for retrieval. Additional staffing will be required. In addition, all contractors' cost data, whether from bids or returned costs, should be automatically made available to the Command's cost estimating focal point, SEA 01G, for input into its data bank.

3. STAFF RESOURCES

Concerns the need for quantity and quality of personnel required to produce credible cost estimates on a timely basis as well as perform the other costing functions separate from cost estimating.

Discussion

The need has been addressed in the SCN, NMARC and other studies. As a result of the 1969 SCN study, improvements were made by establishing a Ship Cost Analysis Group in 1970 to provide needed support to Ship Cost Estimators. Subsequently, however, there has been a continued reduction in personnel with an attendant increase in costing functions. The NMARC study in 1975 made note of this fact as diluting the basic acquisition cost estimating responsibility by adding succinct functions such as Life Cycle Cost, Economic Forecasting, etc., without added resources. NMARC states:

> "Existing Navy cost estimating staffs are professionally competent and produce better estimates than they are generally given credit for. However, they are under-staffed in relation to their workload and are frequently required to develop estimates to a very tight schedule on the basis of very limited data. To ensure integrity ... it is necessary that cost estimating groups in the Naval Systems Commands be given adequate manpower and improved information... "

As the result of the NMARC recommendation, SYSCOMS were directed to submit a staffing plan to support the assigned costing functions. COMNAVSEA memo to VCNM in July, 1975 stated that an increase of 22 persons would be needed over a three year period. As an example of the present deficiency, the entire NAVSEA Command does not have a specific billet assigned for Life Cycle Cost, Should Cost, and Cost Monitoring.

Due to the continued decrease in NAVSEA ceilings, the planned increases for Cost Estimating and Analysis were to be addressed as a separate budget issue. An additional budget for FY 1978 was submitted wherein nine additional people were requested for Cost Estimating and Analysis. While the request was approved with some slight reduction in numbers, no additional ceiling was assigned.

The review of NAVSEA 01G staff indicates that the numbers of personnel fluctuate, the level of experience has materially decreased during the past years, and additional supervisory level staff is required. Also, there is a lack of broad shipyard experience; while this lack is understandable, nevertheless it should be corrected in considering additional staff.

The staffing problem is compounded when considering additional recent needs for improvement in Operating and Support Costing and a proposed PMS 399 improvement plan for GFM. In addition, the aforementioned efforts have addressed NAVSEA 01G as the NAVSEA centralized cost estimating group.

Conclusion

The caliber of key personnel in 01G is excellent and there is a solid base on which to strengthen certain functions and procedures. Despite the prior recommendations and staff budgeting attempts, NAVSEA has not assigned any increase in staffing. Action is required. Furthermore, every effort should be made to recruit experienced shipyard estimators in filling higher grade positions.

4. STAFF TRAINING

Concerns the method of improving the capabilities of personnel through education, updating skills, special assignments, seminars and other specialized training for the various costing functions on a continuing basis.

Discussion

This subject was covered in studies by the Blue Ribbon Defense Panel (1970), Office of Management and Budget (1976), NMARC (1975), and CNM Inspection of NAVSHIPS (1972).

NAVSEA 01G Training Plan has been in existence since 1971 and has as its key:

- An identification of succinct skill and knowledge requirements for each functional position.
- A directory of training available for each skill and knowledge requirement.
- A procedure to determine the extent requirements have been acquired on an individual basis.
- A planned approach toward directing training on a custom basis for each individual.

The NAVMAT/SYSCOM Cost Estimating Improvement Group has established a formal one-week introductory training course, it conducts seminars on a yearly basis, and holds monthly lectures in costing

subjects. It is understood that 96 percent of NAVSEA 01G personnel have received training, averaging 65 hours per employee. This training is also available to non-cost estimators who have a need for related training.

A review of existing NAVSEA 01G staff backgrounds indicates a high level of education, but with very limited experience in shipyard or other practical areas. Training and experience in the shipbuilding process are vital to development of proper judgment in estimators. Field assignments of sufficient duration in shipyards should be provided to selected career-caliber cost estimators as means of acquiring estimating judgments.

New personnel entering as Engineer-In-Training (EIT) Program are assigned to a shipyard for a period of one to three months. Travel funds are stated to be limited, which precludes longer periods of on-site training of EITs and also periodic field assignments of the regular SEA 01G staff.

Conclusion

SEA 01G has an excellent training program, which should be supplemented with additional on-site field assignments for all personnel to acquire practical shipbuilding and estimating experience. Sufficient travel funds should be provided for this program.

5. RESERVES

Concerns the provision of separately identified funds in the estimate to cover estimating allowances for margins, future ship characteristic changes, change orders, and other growth reserves.

Discussion

Shipyard estimators inherently provide various margins, usually of finite magnitude based on experience trends. These could provide for material scrappage, margin for labor productivity in terms of manhours required and the like. However, Navy budget estimates for total program cost also include additional reserves such as for change orders, escalation, PM's growth factor, etc.

Several of the earlier studies indicate the need for adequate reserves as well as contingencies based on the recent great unpredictability of major weapon acquisition. These studies are NAVSHIPS Procurement Review Group (1969), ASPR Pricing (1970), SCIP (1972), NMARC (1975) and Acquisition Advisory Group (1975). Estimates for naval shipbuilding in particular need adequate use of reserves due to the long construction period, technological uncertainty, and other risks. As a general policy, the executive and legislative branches of Government, as well as the reviewing budget analysts within DOD,

do not like margins, reserves, or contingencies as they are considered to inflate the national budget. Further, a Program Manager may want limited reserves as a means of authorizing a larger ship program within a predetermined dollar ceiling.

Some of the funds normally required as reserves could be more specifically included in the base estimate through a more complete product definition and a full understanding of the many economic factors that affect shipbuilding costs which vary from shipyard to shipyard and from region to region. This would not necessarily reduce overall budget estimates, but would limit the funds specifically set aside for usual reserves and margins.

Due to inherent characteristics of naval shipbuilding, there is a valid reason for a contingency for risks and unforeseen events that could materialize during the long design development and construction time. Such contingency funds would have visibility as a lump sum against the total SCN program and would be managed by COMNAVSEA through specific program managers. This would be particularly valid if the budget cost was based on less than a class "C" estimate.

Conclusion

With unpredictable cost trends continuing in the near future and with the nature of the naval shipbuilding process, it is necessary to include sufficient reserves or margins in all budget estimates. In addition, efforts should continue to have the concept of a separate contingency allowed in budgeting of naval ships, especially if the costs are based on less than "C" quality estimates.

6. ECONOMICS OF INDUSTRY

Concerns escalation, marketplace, BLS information, profit considerations, shortages of key material, shipyard interest and others.

(1) Discussion

This is one of the major factors affecting the capability of preparing quality estimates and is emphasized in most of the 20 reviewed studies. Especially important is the recent rapid growth in overhead, an error in which could drastically change an otherwise good manpower estimate. Typical "Economics of Industry" estimating factors to consider are:

- Escalation
- Labor rates and trends
- Productivity
- Market Analysis
- Material Inflation
- Skilled labor availability
- Training programs
- Learning curves
- Administrative cost due to Navy
- Metrication
- Pollution abatement

- OSHA
- EEO
- Energy costs
- Fringe benefits
- Social Security taxes
- Ship scheduling
- Profit

The Cost Analysis Branch of SEA 01G was established to develop and predict these many factors for the Cost Estimating Division. Its staff is numerically insufficient to adequately monitor and predict all economic changes. Its efforts in the more important areas are:

- Material inflation guidance based on inputs from the leading marine equipment manufacturers in lieu of the BLS wholesale price indicesis expected to provide a more realistic measure of inflation; however, a greater information response from industry is desirable.

- Labor rate predictions are thorough and consistent. It is suggested that data be supplemented by the use of current information from shipyards and Navy auditors.

- Overhead increases yearly and, with its many variables, is an important factor. The Branch has developed a computer model with 130 items and proposes at least one model for every shipbuilding region in the country. Branch capabilities can be increased by:

  - Completing proposed overhead models

  - Increase data base from shipyards

- Determine yards' plans for future major facilities

- Provide for overhead costs caused by contract extensions beyond assumed present seven months delay

- Escalation computer programs have been developed by the Branch and the new "Marshall" contract escalation clause was issued in 1975 which corrected many inequities.

- Market analysis is conducted by the Branch to predict workload two years in advance. This hopefully indicates those yards most likely to bid or negotiate, which in turn permits a more accurate estimate of yard conditions and their reflection of ship pricing. It may also enable a more dependable estimate of construction schedules.

- Productivity has generally decreased due to many factors, one of which is reduction in experienced career employees. NAVSEA has already been adding decreased productivity factors to its manhour projections. Due to the sensitivity to total costs, more current productivity information should be obtained from shipyards and other sources as a means of judging trends.

- Learning curves are a critical factor in estimating multiple ship program costs, but mechanization and changes in the industry are destroying former curve projections. The present practice of using cumulative average learning curves for guidance should be modified by analysis of returned costs of recently completed ships.

- Profit provisions comply with ASPR rules which consider provisions for risk, level of performance and development of facilities. Current profit quotations are tracked and the present guidance is considered adequate. Changes in profit application may result from "Profit '76" study.

There are many other economic and cost factors that interlock with those dicsussed above, such as the effect of OSHA, energy costs, EPA, and taxes on shipyard overhead. The review indicates a general lack of firm data on the potential impact of these factors. Current economic and cost data input needs improvement to store and retrieve in a readily available form. Again, additional staff with varying skills will be required to supply current economic factors necessary in developing quality and timely estimates.

(2) Conclusion

Sound economic and cost projections are vital in developing a quality estimate. This can best be accomplished through continued acquisition of current industry economic information, including that from the shipyards, SupShips and Navy auditors. The analysis, storage, retrieval and application of this information and maintenance on a current basis will require additional staffing.

7. DOCUMENTATION

This relates to maintaining complete records covering the entire history of estimates, their development, assumptions and data sources, including

modification and reasons therefor.

(1) Discussion

An estimate of a major weapon system is prepared in good faith based on the best available data. At some later period, usually when higher costs or overruns become evident, the quality of these estimates are frequently challenged.

Several of the acquisition studies such as SCN Study (1969), ASPR Pricing (1970), GAO Estimating in DOD (1972), GAO Acquisition of Weapon Systems (1972), NMARC (1975) and Acquisition Advisory Group (1975) emphasize the requirement for good documentation. This overall report on "Ship Acquisition Cost Estimating in the Naval Sea Systems Command" and its relation to ship cost overruns is ample reason to fully document every step of the estimating process.

Documentation is required by DOD and most recently covered in NAVMAT INST 7000.19A of 30 July 1976. A standard COST ESTIMATE DOCUMENTATION SUMMARY FORM (NAVMAT 7000/2 7/76) sets forth the information to be furnished. This is for use outside of NAVSEA. This summary covers only the highlights, namely:

- Technical Characteristics
- Cost and Procurement Assumptions
- Developmental and Risk Considerations

There is also a more detailed documentation developed for internal SEA 01G use, which goes into greater depth. Good records must indicate every phase of an estimate development, including not only the basic items covered in NAVMAT 7000/2, but also all data sources and input, modifications whether made by SEA 01G or others, and directives affecting the estimate, from early planning to conclusion. This compels those developing programs and estimates to fully justify decisions. Good documentation is the estimator's tool as a means of reconstructing events at a later date.

The 1969 SCN Study prompted NAVSEA to develop a documentation program prior to OPNAV and NAVMAT directives in 1973. It is also necessary to document cost estimates of major GFM for which NAVSEA 7300/4 form has been developed. SEA 01G has three staff members who review GFM pricing information for:

- Inflation rates
- Learning curves
- Inclusion of proper support costs

(2) Conclusions

Documentation is being only partially practiced in NAVSEA. Its importance warrants that complete centralized records be maintained

to cover every phase and element of the entire estimating process including GFM. In addition, all modifications, whether made by NAVSEA or others, and the reasons therefor should be recorded. The documentation information should be readily available and maintained for a sufficient period of time.

8. INDEPENDENT REVIEWS AND AUTHENTICATION

This relates to the review, rationalization and acceptance of an estimate by a higher authority.

(1) Discussion

Several of the studies, namely ASPR Pricing (1970), two GAO (1972) and NMARC (1975) advocate an independent review of estimates. At the same time NMARC recommends a reduction in layering of cost estimating and layering of the review and analysis of cost estimates.

The need for independent reviews is highlighted by the problem of cost credibility which is facing the military services. NAVSEA and the other SYSCOMS within NAVMAT have established review procedures. After review and authentication by CNM, budget estimates are transmitted to NAVCOMPT for final Navy coordination and review. The Systems Analysis Division (OP 96) also makes and validates estimates

in support of the DSARC process, but does not validate budget estimates.

NAVMAT INST 7000.19A (30 July 1976) specifically requires that every official major weapon system cost estimate transmitted outside the Naval Material Command must be documented by the originator of the estimate, reviewed by the applicable SYSCOM CAEG and authenticated in writing by CNM. Authentication involves all aspects of the estimate with special reference to policy, technical definition, rationality and overall reasonableness.

Each estimate is also subject to a SYSCOM review for POM/Budget submission. In NAVSEA, all SEA 01G estimates are reviewed by SHAPM, with unresolved differences submitted to COMNAVSEA for resolution. There is also a Budget Review Board consisting of NAVSEA Directorates; however, it is not staffed to perform detailed reviews of ship estimates.

(2) Conclusion

There are no procedures established for complete independent reviews and authentication of ship end cost budget estimates by higher authorities. It is, therefore, suggested that a higher level review be made of each budget estimate prior to being submitted to DOD.

9. REALISTIC CONSTRUCTION SCHEDULES

This relates to realism of proposed construction times, ability of contractors to meet schedules and ability to award contracts at the approximate time anticipated in developing the budget. While construction schedules are not a cost estimating function, the preparation of these schedules by other offices has a significant impact on the final estimate.

(1) Discussion

One of the significant cost drivers is the general inability to meet the budgeted construction contract date and the expected completion time. For example, CVN 69 will have an anticipated cost overrun of about 52 percent, a significant segment of which is due to shifting labor application caused by a 3-1/4 year delay in ship completion. The impact of incorrect delivery date predictions in the estimate is evident.

Five of the major Acquisition Studies, including SCN (1969), NMARC (1975) and OMB (1976) were emphatic that estimates should be based on realistic construction schedules. Other than delays accepted under the contract which are beyond the control of the contractor, there are a number of other basic causes for not meeting schedules, namely:

- Design changes during construction
- Over-optimism by contractor
- Over-optimism by Navy estimators
- Over-optimism by Navy program planners
- Late and defective GFM
- Capability and performance of shipyard

Over-optimism by the contractor is frequently and unwisely motivated by the desire to meet Navy program objectives. The Navy planner may sometimes establish unrealistic ship schedules in his zeal to meet national defense requirements and to obtain necessary appropriations, although awards may be delayed.

Over-optimism in developing construction schedules usually stems from insufficient information on shipbuilders' capabilities, economics of the industry and general market conditions. Even though the estimate may provide for an attainable building schedule, delays in making the award also occur. NAVSEA estimates for contract escalation usually provide margins for a possible seven months delay factor. This may be insufficient until shipbuilders with historical records of delay work off their backlogs and demonstrate ability to meet present anticipated schedules. Unfortunately, many shipbuilders have difficulties in meeting both naval and commercial contract delivery dates, hence the issue is

critical. The capability of the shipyard to meet schedules is largely dependent upon adequate management, labor availability and productivity, facilities and engineering.

It is apparent that realistic ship construction schedules are essential for quality estimating. Predicting the capability of the shipbuilding industry to build specific ships at specific times is the responsibility of the Industrial Activity Work and Resources Planning Division (SEA 071). While this Division has other resource planning work, the importance of accurate ship schedules leads to the belief that both SEA 071 and SEA 01G be merged either organizationally or placed under a common supervisor, as was the case several years ago.

In addition, an expanded, in-depth development of ECONOMICS OF INDUSTRY information will assist in projecting more realistic construction schedules.

(2) Conclusion

Due to the importance of developing realistic construction award and completion schedules, the following action is desirable:

- Develop in-depth information and analyze factors relating to individual shipyard performance and the ability to meet proposed schedules.

- Budget estimates should be based on the latest and best available judgment.
- SEA 071 and SEA 01G should be merged organizationally or placed under a common supervisor with shipbuilding responsibilities.
- Program contracting dates should be met or additional funding margin provided for contingencies.

10. RELATED COSTING FUNCTIONS

This is the performance of Related Costing Functions, or more specifically, related cost estimating and analysis functions where some aspect of acquisition costing is involved, such as life cycle cost, should cost, technical analysis review (TAR), economic analysis, design to cost, field audits and other techniques to improve the overall acquisition estimating process.

(1) Discussion

There are numerous related cost estimating and analysis functions that NAVSEA is required to perform under various directives. The descriptions, directives and responsibilities are covered in greater detail in another section of this report. The related costing function importance has been particularly noted in the NMARC Study (1975). This study recognized the need for various cost analysis efforts and stated that many functional responsibilities in this area have been added to the SYSCOMS without added resources to carry out the functions and

as a result dilute the basic budget cost estimating responsibility.

NAVSEA 5400.1 assigns SEA 01G as the Command focal point for many of the related cost estimating and analysis functions. The Cost Analysis Branch (SEA 01G2) is delegated the responsibility for performing much of the work. A review of SEA 01G2 performance reveals that staff and time limitations prevent full compliance with DOD and DON directives. Work is accomplished only whenever possible and when sufficiently high priorities are established.

The ever increasing military budget and the many large overruns being currently experienced have led to a reemphasis of performing the basic budget estimating function. Some of these cost estimating and analysis functions are properly within the purview of SEA 01G, while others could be delegated elsewhere within NAVSEA. In either case, proper staffing is required if all are to be accomplished.

(2) Conclusion

Compliance with existing related costing function directives is not being fully met by SEA 01G due to limitations of available time and staff. This condition may be improved by:

- Assignment of selective functions to other NAVSEA groups

- Limiting SEA 01G participation to current levels of effort
- Assignment of only high priority studies to SEA 01G
- Make selective staff increases in SEA 01G to meet responsibilities

11. CENTRALIZED ESTIMATING

This relates to a centralized estimating group which acts as the focal point within each Command and is responsible for cost estimating, policy and guidance.

(1) Discussion

Several of the recent studies relating to cost estimating and shipbuilding such as the CNO (Holloway) Study (1967), CNM Inspection of NAVSHIPS Report (1972), and NMARC Study (1975) have recommended the need for centralized estimating.

NAVMAT INST 7000.19A requires that within each SYSCOM there shall be one focal point, referred to as the Cost Analysis and Estimating Group (CAEG), which is responsible for cost estimating policy and guidance.

NAVSEA INST 5400.1 delegates this to the Cost Estimating and Analysis Division (SEA 01G) as the Command focal point for all estimates.

This division ensures that all estimates emanating from the Command are professional and consistent, including providing staff assistance and advice on cost estimating to all headquarters and field organizations.

(2) Conclusion

Centralized estimating responsibility within NAVSEA and the delegation of SEA 01G as Command focal point for all estimates has been complied with.

12. CLASSIFICATION OF ESTIMATES

This relates to performing the highest quality estimate commensurate with requirements.

(1) Discussion

Several of the studies, particularly SCN (1969), and NMARC (1975) express concern about the quality and credibility of budget estimates. The SCN study recommends an appropriate classification system to indicate the level of information available to the estimator. This was subsequently developed by SEA 01G and implemented by OPNAV INST. 7720.2. NMARC urges that the use of less than class "C" estimates be diminished. It also recommends a contingency whenever less than budget quality cost estimates are included in the budget.

The system of classifying estimates to a proper level of confidence is sound. Unfortunately, with the rapid development of programs and the many subsequent variables introduced by the Navy, Congress and the Executive Office, the estimator may neither have an adequate technical definition, nor the time in which to prepare a budget quality estimate. Several years ago -- during periods of predictable contracting markets -- the development of estimates was less complicated. At present and in the foreseeable future with the rapid change in costing and pricing factors, the need for quality estimates becomes increasingly apparent.

The 1977 GAO Report "Financial Status Of Major Acquisitions" as of June 30, 1976 indicates that estimating represents an average of 8.8 percent of the overruns experienced in the 53 Defense Acquisitions analyzed, while 46.5 percent of overruns were caused by economic factors. The Blue Ribbon Defense Panel Report indicates that about 15 percent of the cost growth in major programs during the 1960's can be attributed to the inherent imprecision of present cost estimating procedures. Shipyards or other commerical ventures could not tolerate errors of this magnitude and remain in business.

One point at issue is whether the nine group estimating system historically used by NAVSEA is of sufficient accuracy, assuming all the

other estimating variables have been properly accounted for.

(2) Conclusions

A proper estimate classification system has been established since 1969 and is in use. A more detailed estimating system should be used when all the necessary information to perform such a detailed estimate is available.

13. BUDGETING PROCESS

This relates to non-estimating influences in the Budgeting Process that modify acquisition estimates to reflect program and ship definition changes, policies, changes in estimating factors such as inflation, overhead, profit and delivery schedules, contingency margins and others, either with or without compensatory changes to baseline estimates.

(1) Discussion

The Budgeting Process has emerged in eight of the major acquisition studies that were reviewed as being critical in the development of rational acquisition estimates. These studies are the CNO (Holloway) Study (1967), NAVSHIPS (Sanders-Scanlon) Study (1969), SCN Study (1969), Blue Ribbon Defense Panel (1970), Acquisition Advisory Group (1975), NMARC Study (1975), ASN Inflation Study (1975), and GAO Status of

Major Acquisitions Report (1977).

The GAO Report of 1977 states:

> "In some instances, the initial or baseline estimates may then include higher cost predictions than considered acceptable to the agency submitting budgets for favorable Congressional and Executive consideration."

The SCN Study (1969) warns of reducing budget prices of ships below those developed by professional ship cost estimators. The SCIP Report (1972) recommends that OPNAV issue a policy that deviations in CNO-SCN management policy, such as authorizing changes in characteristics without compensation or without Future Characteristic Changes (FCC) funding, are authorized only by CNO/VCNO. In a similar vein, the NMARC Study (1975) states:

> "Positive measures should be taken by OPNAV to ensure that changes to program scope and requirements are accompanied by corresponding adjustments to cost estimate baselines and budgets."

The review of the ship program budgeting process shows that baseline estimates are frequently modified downward without compensatory changes in ship characteristics or other factors.

Thus, the Budgeting Process should be carefully managed and supported to ensure that acquisition budgets reflect credible estimating and that any program adjustments or changes are properly included in

the budget estimates. Within NAVSEA, there are procedures whereby SEA 01G has direct access to the Commander in the case of disagreements over cost estimates. At that stage, the decision rests with COMNAVSEA, CNM, CNO, etc.

(2) Conclusion

The Budgeting Process is a key element in preparing credible estimates. Despite the complications and policies of developing acquisition programs, the budgets must reflect estimates within which the programs may be successfully completed with a minimum risk of contractors' claims or budget overruns.

14. COST CONTROL MANAGEMENT

This relates generally to the cost control period after the budget has been submitted, from contracting through the completion of the weapon system. Cost control, in this sense, is a series of procedures whereby each SCN project is continually monitored for potential problems -- whether cost is on target, whether contract difficulties are appearing, whether potential for a claim situation exists, etc.

Discussion

The need for adequate cost control management ranks high in the various recommendations developed in acquisition studies. The SCN study refers to it as "The Cost Control Period" during which the Navy should maintain fiscal control of the programs. Cost Control was mentioned in the early 1939 Bureau of Supplies and Accounts Study, reiterated through several other reports, and finally in the 1975 NMARC, ASN Inflation and Acquisition Advisory Group Reports.

DOD Instruction 7000.2 establishes the need for each Command to develop Contract Cost Data Reporting (CCDR) for each program. These reports are used for surveillance of contractors' progress and to ensure that contract cost and performance information are being obtained. SHAPMs and Project

Managers receive the periodic reports for evaluation, as part of their program cost management techniques. This cost management procedure provides a basis to assist:

- DOD managers in assessing the credibility of SYSCOM estimates for follow-on programs.
- Project Managers and SHAPMs to evaluate their programs from a cost and schedule standpoint.
- Estimating groups with feedback as a means of evaluating weapon cost and price trends.

Conclusion

An effective cost control management system requires receipt of periodic, detailed scheduling and cost information from the contractors. These reports should be carefully monitored and analyzed by SupShips and forwarded to Project Managers and SHAPMs for appropriate consideration. In turn, the reports with final analyses should be sent to the estimating groups for use in preparing current and future program estimates and cost projections.

At present, only limited cost management information is made available to SEA 01G and thus is generally unavailable as an additional source of data to project cost trends.

EXHIBIT B.1

STATUS

OF

RECOMMENDATIONS

AD HOC COMMITTEE ON

NAVY SHIPBUILDING PROCUREMENT

PROCEDURES - SHIPBUILDERS

COUNCIL OF AMERICA

MAY 1977

SHIPBUILDERS COUNCIL OF AMERICA
REPORTED
STATUS OF RECOMMENDATIONS
MAY 1977

[Specific Recommendations Are Underlined]

Source: HAC Report
3/22/77

NAVY COMMENT (Accommodated (A))	SCA COMMENT
(1) "Continue Progress Payments on basis of Physical Progress As the letter of the Shipbuilders Council noted, SECNAV INST 7810.12 of 17 July 1975 largely preserves the concepts of progress payments based on physical progress.	(1) This action of accommodation alleviates problems of cash flow probably to the near maximum expectable extent. Superior to other clauses used in weapons systems other than ships.
(2) "Examine Governmental organizational structure bearing on ship procurement and production" As the Council stated, there have been numerous studies into the organizational structure bearing on ship procurement and production. These studies have ranged from the overall Department of Defense review conducted by the President's Blue Ribbon Defense Panel in 1969 and 1970 to the more recent assessment of the Navy's organization management, staffing and procedures in developing and producing weapon systems made by the Navy and Marine Corps Acquisition Review Committee (NMARC). Recommendations were made by these reviews and changes made.	(2) No perceivable change for the better has occurred from NMARC recommendations.
More recently the Chief of Naval Operations directed the Chief of Naval Material to examine the readiness of the Naval Material Command and the component Systems Commands to respond to the Navy's material acquisition and maintenance programs, with special emphasis on shipbuilding and the Naval Sea Systems Command (NAVSEA). The initial action of the Commander, Naval Sea Systems Command (COMNAVSEA), was to assign Rear Admiral E. J. Otth, USN, to the position of the Special Assistant for Shipbuilding. Reporting directly to COMNAVSEA, this office is to provide command level coordination, integration and oversight of the NAVSEA functions necessary for highly effective performance of the shipbuilding mission. One of Admiral Otth's initial efforts is to perform an assessment of and recommend improvements for the NAVSEA organization. This effort is being given priority within NAVSEA and is second only to matters pertaining to claims litigation and adjudication. He intends to solicit the advice of knowledgeable individuals in the government and in industry to obtain a comprehensive evaluation of planned improvements. The Shipbuilders Council will be advised of significant changes.	The apparent attitude approach of present COMNAVSEA instantly augurs well toward improvement in relationships.

NAVY COMMENT Not Accommodated (NA)	SCA COMMENT
(1) "Accept full cost responsibility for deficient specifications, GFI and GFE" (2) "Accept full cost responsibility for schedule and production delays caused by government action or inaction" (GFE, GFI) It is acknowledged that problems of delay, defects and omissions occur with GFI and GFE. The Navy is continually trying to improve this situation. For example, the Trident Project Manager has established a process by which the contractor, the Supervisor of Shipbuilding and the Navy Project Office can within two working days identify the problem, provide immediate solution and authorize the contractor to take corrective action.	(1, 2) There is considerable evidence of movement toward acceptance by Government of cost responsibility in these areas. Indirectly, the new escalation clause, which for purposes of escalation impact on all delays, no matter which party the cause, accepts full Government responsibility for the delay, is one major movement.
The LHA Project has always been agreeable to accept full cost responsibility for deficient specifications, GFI and GFE. For the most part, LHA specifications are contractor developed and responsibility rests with the contractor.	This appears to be a fact.
In general, the problem is defining and supporting the impact of deficient specifications, GFI and GFE, and obtaining reasonable proposals on price and schedule. The tendency is for the contractor to inflate the impact and for the government to estimate the impact as much less. This leads to hard and extended negotiations and delays in settlement.	At least, this is recognition by the Government that there is a problem. However, Government tends to resist admitting if made a "mistake". True impact on industry of the "mistake" correction when Government gets to point of recognition is difficult to assess with precision.
(3) "Defer change in primary specifications until after delivery of ship" (4) "If impossible, issue instructions for change early in construction cycle" The basic evaluation of any change to specification made after contract, must consider the mission, operational or safety requirements. Where any of these requirements are involved the decision then becomes one of whether to accomplish prior to or after delivery. Here the government must evaluate the impact of the change and estimated cost to implement, either before or after delivery. It is recognized that the risk/responsibility must be assumed by the government when making this decision. All government responsible changes that resulted from the INSURV Inspection of LHA-1, except critical or safety types, have been delayed till the Post Shakedown Availability of the Ship. Also, any of these changes applicable to LHA-1 through LHA-5 will not be performed if they will cause any delivery delay to those ships.	(3,4) As is applies to "relationship" problem, the question of primary specification change control appears to be of lesser significance than the one of early recognition of "mistakes" in (1,2) above and early issuance of change order to proceed with correction.

NAVY COMMENT	SCA COMMENT
(5) "Arrange for provisional pricing of change order of obvious high dollar value" (6) "Finalize pricing of these major change orders with dispatch" Present practice permits pricing of changes with maximum or minimum pricing with requirement for the contractor to submit pricing progosals, within a certain time period, and then for final price negotiation. Here again the defining of impact of the change and negotiating settlements depends on the reasonableness of both parties. The mutual desire to "finalize change orders with dispatch" is often frustrated by late or inadequate cost proposals from the contractor. To the extent that cost proposals for essential changes can be promptly and accurately developed, changes can be adjudicated promptly.	(5,6) Here, recognition of the problem is evaded. In cases of many changes of obvious high dollar value, it is impossible both for the contractor to price and Government to evaluate proposed pricing until considerable time has elapsed - yet both parties have grasp of "ball park" value and, absent pricing agreement, contractor must bear work-in-process costs of the change. Provisional pricing is a way out of the dilemma - this is different from a "max-min" pricing action which infers a more nearly specific knowledge of pricing probabilities, arrived at only after considerable time for work. (6) Certainly is a two-party street. Often the contractor is reluctant to submit an early, negotiable, pricing proposal.
(7) "Rely on contractor informational systems to maximum practicable extent" The implementation guide for DODI 7000.2, the current management system requirement for major DOD procurements, including ships, states "By applying criteria, rather than specific DOD prescribed management control systems, contractors have the latitude and flexibility for meeting their unique management needs. This approach allows contractors to use existing management control systems or other systems of their choice, provided they meet the criteria." The Naval Material Command, the Naval Sea Systems Command and the individual Ship Acquisition Project Manager policies and practices support that concept. Only those systems or system components that do not meet the criteria are required to be changed and then only as necessary to comply with the criteria. NAVSEA's experience in reviewing the various shipbuilder management systems revealed that in some instances the systems were deficient in measuring performance at the various levels within the company. These systems required modifications to give internal management and the government more accurate data in order to make responsible decisions. Recently one shipyard was validated with only minor changes to its basic system. The key is mutual agreement with the contractor to obtain cost performance reports which will be useful to both the Navy and shipyard management.	(7) Here is the start of clear evidence of Navy's obvious low esteem of shipbuilder management system practices. Whether or not that low esteem is warranted, it exists. The Bennett memo of 1/31/77 on 7000.2 perhaps affords the opportunity to clear the air. Some of these Navy views come from shipbuilding-capable people - and some views may have merit.
(8) "Reduce government-imposed reporting requirements"	(8) This one makes it clear that Navy know it "runs a paper mill" and is not dedicated to lessening the mill's volume. It would be tilting at windmills to pursue further "as long as it is paid for."

NAVY COMMENT	SCA COMMENT
(9) "Eliminate superfluous and nonproductive requirements"	(9) This is in different context from (8)'s "paper mill". It fundametally says that Navy' call for a "cadillac both in administration and production when a Model T is all that is needed". Navy recognizes the validity of the criticism to some extent but says it isn't changing its ways appreciably.

Navy shipbuilding contracts do require extensive paper work and reporting requirements. Much of this is caused by Navy's need to manage the program, assure technical acceptability of the product, and to prepare for logistic support. Other requirements stem from higher authority and laws passed by the Congress.

The Navy requires that shipbuilders operate a DODI 7000.2 compliant management system for major ship construction/design effort. The Cost Performance Report (CPR), DODI 7000.10, is the major management report required and is a direct output of the compliant management system. This data, supplemented by schedule status information, is intended to accommodate most of the Navy's needs. Unfortunately, most shipbuilders are not yet operating management systems which can be validated. As a result, more extensive interim reporting is required to insure satisfactory Navy visibility of cost and schedule status.

Where possible, the Navy has attempted to simplify its requirements. The AGOR 21/22, the T-ATF and the T-AGOS (proposed FY 79) are or will be of commerical design. In their procurement, the minimum amount of reporting is required. However, these are rather simple ships without the mission requirements which necessitate the more sophisticated documentation.

NAVY COMMENT	SCA COMMENT
(10) "Limit role of DCAA to financial accounting" (11) "Restrict DCAA activities to verification of contractor's costs and forecasts of costs" (12) "Consolidate DCAA functions and those of Navy Supervisor of Shipbuilding in contractor's plant"	(10,11) Navy simply says flat out, "It is not expected that the role of DCAA will be reduced". DCAA's role, it might be noted, is dictated by OSD rather than by Navy. The power and authority of DCAA is in fact, growing, both in context of access to records and vis-a-vis the authorities of the Contracting Officer. (12) This says that Navy is trying at least to avoid duplication in DCAA/Supships surveillance. Could help or could be meaningless.

To adequately perform their assigned role, DCAA must fully understand the many operations of the company. All of these operations generate cost and their allowability must be determined. DCAA is interested particularly in the areas that deal with establishing salary structures, organization, acquisition and utilization of personnel. Also of interest are the controls exercised to insure reasonable overhead expenses and the validity of financial reports furnished to the government or used internally to project cost growths or otherwise manage the company's operations. DCAA's primary emphasis is on cost avoidance. It is not expected that the role of DCAA sill be reduced.

NAVY COMMENT

Efforts have been undertaken to reduce the impact of audits imposed on shipbuilders by both the Supervisor of Shipbuilding and DCAA. Implementation of a Memorandum of Understanding between the Navy and DCAA designed to coordinate their reviews has proven successful. This procedure will be in effect for all audits of contractors having a contract over $25 million. Although not lessening the overall surveillance, it is expected that this coordination will reduce the impact on shipbuilders.

(13) "Revive practice of reliance on approved contractor purchasing system"

(14) "Eliminate review and prior approval of each proposed subcontract"

(15) "Cancel NAVMAT Notice 4330, dated November 1973, entitled 'Surveillance of Sub-Contracting Operations'"

Navy's policy concerning the approval of major shipbuilders' procurement systems has been changed. Contractors' procurement systems, when warranted, are now approved by the Navy. For example, Ingalls' procurement system was approved on 3 December 1975.

Each proposed subcontract has never required prior Government approval. Only those subcontracts in excess of certain dollar limits for certain types of contracts require prior approval. For example, when the prime contract is a fixed priced incentive type, only proposed firm fixed-price subcontracts over $100,000 require approval. Where contractors have approved procurement systems the dollar limit may be raised or eliminated althogether.

Surveillance of a contractor's procurement system is an ASPR requirement which accounts for continuing the NAVMAT provisions in other applicable sections of Navy procurement Directives. The "heavy government monitoring" mentioned by the Council consists of a part-time effort at most of the shipbuilders. Only at the three largest shipbuilders is there a full-time procurement surveillance analyst. Considering what most of the shipbuilders procurement track records have been to date, it is not anticipated that government surveillance will be discontinued.

SCA COMMENT

(13,14) These are sensitive points with practically the whole shipbuilding community. On the other hand, people (in Navy) who know both purchasing and the production/supply requirements back of purchasing - and the practices of a number of industries in purchasing - believe unequivocally that shipbuilders have the poorest system in existence.

At the same time, the supplier industries (generally) would prefer to sell direct to the Navy than to the shipbuilder. There must be some clue in all this to an underlying problem - perhaps it could be explored in conjunction with 7000.2

Navy's comment on (14) is both superficial and supercilious. The "trouble" contracts start at the $100,000 level.

(15) The last sentence of Navy comment makes Navy attitude clear. Actually, ASPR content now is, if anything, more severe in its requirements on primes for subcontractor surveillance than was NPD at the commencement of the 1974 Ad Hoc Committee position development.

NAVY COMMENT (Accommodated In Part (AIP))	SCA COMMENT
(1) "Authorize interest cost of borrowed funds as allowable expense items" You have noted that CAS #414 recognizes cost of facilities capital as an allowable expense. There is no present intention, by DOD, to expand this policy to include the cost of working capital as an allowable expense in the performance of DOD contracts.	(1) Resolution of this matter is a problem for OSD, not Navy. At this moment, Navy comment is appropriate. However, this question needs to be addressed at every opportune moment as time passes.
(2) "Resolve outstanding claims quickly and take all steps to minimize future claims" Claims teams are functioning at Ingalls Shipbuilding Division and Newport News Shipbuilding and Drydock Company. The claims team manager and the team leaders have been selected for General Dynamics, Electric Boat Division, and are on board. These leaders are hiring the necessary people for an accelerated evaluation and settlement. An in depth assessment of the EB claim adequacy is being made. If any new claims are submitted, new teams will be set up as necessary.	(2) So much has been written on this subject as to make it one no longer treatable under initial ad hoc paper representations.
The Navy has three concurrent studies underway to arrive at a solution to the same "delay and disruption" pricing problem. These studies, each using a different method, are not expected to be completed until late 1977. Upon completion the Navy hopes to be able to insert new clauses in contracts, agreeable to the contractors and the Navy, which will make the pricing of delay and disruption in changes a pre-priced element.	Finding acceptable formula(e) for simplistic solution of "delay and disruption" problems may be difficult. Any "new clause" content should be weighed carefully.
A special task group has been set up in NAVSEA to study and recommend action to minimize future claims. In addition, claims prevention teams are being staffed at the SUPSHIPS that deal with new construction contractors. These teams will be tasked to report any potential claims that they observe. In this manner the Navy hopes to be able to settle problems promptly before they become a claim.	
It must be noted, however, that claims settlement is a two-sided problem. First, the shipbuilders must present their claims properly documented with details and facts supporting their claims. Secondly, the government must fairly evaluate the claim and then negotiate. Regrettably, claims are an adversary situation and by their very nature must always be. However, if both sides act as reasonable parties, resolution should be forthcoming without excessive delays. Delays just cost both sides added dollars.	

NAVY COMMENT | SCA COMMENT

(3) "Pending affirmative action in cited problem areas, adopt some type of cost reimbursement, assured fee, contract and if appropriate, restructure existing fixed price type contracts as cost type contracts"

The "Report by the Seapower Subcommittee of the Committee on Armed Services House of Representatives" dated December 31, 1974, contained ten recommendations. Recommendation number eight stated, "The subcommittee recommends against any open-ended, cost plus contracts for naval vessels." In the response to the subcommittee on June 3, 1975, the policy of the Department of Defense was reaffirmed in the statement: "Ship construction contracts should be of a type appropriate to the level of risk involved in their performance: generally, cost-type for lead ships and fixed price incentive for follow ships." This will continue to be DOD policy for future shipbuilding contracts.

As to restructuring existing contracts, you are very familiar with the efforts of a year ago to provide some relief under P.L. 85-804. In the absence of alternatives, such as P.L. 85-804, the Navy does not have the authority to restructure existing fixed price type contracts, as you suggest.

SCA COMMENT (3) For contracts placed since time of this recommendation, Navy has adopted either cost reimbursement type, or Fixed Priced Incentive type with wide spread from target to ceiling costs and prices.

The efforts of Secretary Clements in this direction are well known and fully documented. Navy enthusiasm regarding those efforts is at best questionable. Navy has authority to institue the efforts but did not exercise it. The efforts were instituted at OSD level.

(4) "Recognize that through government action or inaction financial and performance risks are being imposed on contractor resulting in costs that exceed impact from inflation"

The causes for delay are often due to actions of both parties. In these cases both parties should share costs. The Navy is willing to assume its share of costs that are caused by unilateral actions of the government.

SCA COMMENT (4) This is a self-serving response. Overall, it is believed here that Navy, particularly 08 segment, does not recognize cost impact of Government action or inaction.

(5) "Recognize that primary specifications inherently contain errors and inconsistencies"

(6) "Provide for prompt corrective changes"

There is no question that there are some errors in ship specifications. These are corrected by contract changes as expeditiously as possible after they are identified and confirmed. The Navy's policy is to issue change orders as soon as problem areas requiring action are identified. Average time to issue change orders in some projects has been three months from start to finish. Time required to complete negotiations and pricing of the change depends on staffing and workload at the respective contractor, SUPSHIP, or NAVSEA office. An average of three months is required for final adjudication after the approved change leaves the Navy Project Manager's office.

SCA COMMENT (5,6) Last sentence is fully appropriate to problem solution. Navy at least seems to recognize that it is a contributor to the problem.

NAVY COMMENT | SCA COMMENT

Here again the shipbuilders and the government are in an adversary position. What the shipbuilder may consider as an error for his benefit may be just a matter of interpretation. Negotiation by two reasonable parties is all that should be required.

(7) "Improve accuracy of definition of ship to be built"

A continuing goal of the Navy is to turn out the best "defined" ship. A significant expenditure of resources are applied to this goal.

In FFG-7 Program, the ship definition (in the form of systems drawings and working drawings and component purchase specs) has been greater than for any previous procurement. Although this is in keeping with Navy intentions to provide maximum possible information to industry for bidding purposes, it has caused one yard to complain that the data provided with the FFG RFP was too bulky and extensive and tended to increase costs to prepare proposals.

Each iteration of a new design builds on a preceding specification taking into account problems and lessons learned on the previous design. Unfortunately, a Navy ship is not a simple undertaking. A myriad of players enter and leave the arena during the evolution from conception of a ship until the last of the class is delivered to the fleet. Changes will occur. Keeping these changes to a minimum and prompt adjudication of impact of required changes is the end goal to which the Navy is striving.

SCA COMMENT (7) Shipbuilders Council's 10/20/76 analysis of status agreed that "Government is trying".

(8) "Outlaw 'auction type' bidding techniques as basis for contract negotiation"

The Navy is not aware of any situation that could be construed to have been an auction.

ASPR Section 3-805 requires that discussions be conducted with all responsible offerors determined to be within a competitive range in negotiated procurements. The principal purpose of these dicussions is to advise offerors of deficiencies in their proposals. The ASPR further requires that, after discussions, offerors be given an opportunity to submit "best and final" offers. As ASPR Section 3-805(c) specifically prohibits the use of auction techniques, the Navy would appreciate knowing of any case where this prohibition has been violated.

SCA COMMENT (8) Clearly, Navy does not understand, or refuses to recognize, what is "auction-type" technique. "Not aware" - how could they fail to see DD-963 and many other subsequent "best and final" as "auction-type"? OSD, however, appears to be trying to rectify by "source selection before pricing".

(9) "Issue change orders promptly to rectify delays, defects and omissions" ("As they pertain to GFE, GFI")

(10) "Issue change orders promptly to rectify effects of government action or inaction (as these pertain to other than GFE, GFI)"

It is basic Navy policy that changes should be issued as expeditiously as possible after need is defined. The government does not always agree with the contractor when he wants a change for his benefit. A contractor proposed change must be supported by adequate documentation. Too often, the contractor's desire for a change is not supported by facts.

SCA COMMENT (9,10) Despite assertions, Navy does have attitude of "our inventions (GFI, GFE) are sacrosanct".

NAVY COMMENT

(Accommodation Unknown But Largely Doubted)

(1) "Insure that changes are essential and will minimally affect production schedules"

Changes are universally limited to mandatory items necessary to insure that the ships, as built, will meet mission requirements and will be free of safety deficiencies. Defects and omissions in the specifications are similarly corrected. Each change is scrutinized by a Navy Change Review Board to insure that only essential changes are imposed on the shipbuilder. Decisions consider status of construction and the impact on critical trades.

(2) "Accelerate efforts to simplify primary and subordinate specifications"

Simplification of specifications for sophisticated systems and equipments, and for Navy ships is not possible. Clarification should be and is the goal of the Navy.

(3) "Eliminate requirements of doubtful value and uncertain cost"

Where possible Navy is attempting to tailor requirements to fit the needs of the ships. There has been some success in the auxiliary ship program. An example of this is the use of the less stringent MIL-I-45208A quality assurance requirement instead of MIL-Q-9858 on the AO (Fleet Oiler) program. Efforts continue to get mission ready ships at the most economical price.

(4) "Improve accuracy of forecasting probable costs"

A continuing effort to improve the accuracy of forecasting probable costs has been underway in the Navy. In particular, considerable improvements have been made over the past few years relating to the forecasting of "inflation" (shipbuilding material costs up to contract award) and "escalation" (use of BLS indices in the contract award). A summary of these improvements follows:

Escalation - Commencing in 1975 NAVSEA developed a comprehensive in-depth report of the forecast of the BLS indices to be used in budgeting for contract escalation. These forecasts receive in-depth review by the Navy Comptroller and OSD prior to their use. The forecasts are based on projected price movements of the material commodities that affect the indicies, expected wage agreements and other economic factors impacting both material and labor. The Navy and Marine Corps Acquisition Committee Report (NMARC) and the ASN(FM) Inflation Study have both considered NAVSEA's approach to be both realistic and professional and one that other Systems Commands should follow.

SCA COMMENT

(1) It is recognized that this is a "goal", probably impossible of total accomplishment.

(2) Navy has made a reasonable response at least on the surface. Clarification and assurance of consistency between interdependent specifications would seem to be the more appropriate goal.

(3) It is doubted that reply could have been expected to say much else.

(4) This contemplates far more than improving quality of inflation forecasts. Probably, recent study efforts to find out "what's wrong with our estimating system" is a far more significant effort to "improve accuracy".

NAVY COMMENT	SCA COMMENT

Inflation - Commencing in 1973 NAVSEA has solicited the major marine vendors for pricing information, trends and forecasts for their specific marine equipments. This approach is considered more realistic in estimating the basic contractor's costs than the use of broadly based BLS indices. At the onset in 1973 approximately 12 vendors were solicited. In developing the current budget guidance as many as 150 marine vendors have participated.

Participation in Inflation/Escalation Study Groups - NAVSEA is an active member in the Navy Steering Group on Inflation/Escalation whereby there is a mutual exchange of economic information between the Systems Commands as well as access to forecasts by the leading private economists. In addition, NAVSEA is participating with the Bureau of Economic Analysis, Department of Commerce in the development of improved indices for shipbuilding. This particular effort will provide for inputs from the leading marine vendor and shipyards as well.

(5) "Provide reasonably for known and unknown contingencies"

The Armed Services Procurement Regulation Manual (ASPM No. 1) does allow consideration for "contingencies." However, it must be remembered that risks must be assumed by both the government and the contractor. The goal should be a reasonable balance of risk between the government and the contractor.

(6) "Improve accuracy of GFI"

An instruction issued by the Naval Sea Systems Command in January 1976 provided improved procedures for the management of GFI. One of the features of the improved procedures is a requirement for Participating Managers (PARMs) (those Navy organizations that have responsibility for hardware acquisition) to perform a quality review of GFI accuracy and adequacy prior to delivery to the shipbuilder. Another feature is a GFI Deficiency Report by which the shipbuilder shall report GFI deficiencies for government corrective action. The designation of a central GFI agent at the Naval Ship Weapons Systems Engineering Station, Port Hueneme, California, is also expected to provide additional improvement.

(7) "Recognize cost and production consequences of erroneous and incomplete GFI and delayed delivery of both GFI and GFE"

The NAVSEA instruction of January 1976 on GFI management provides a contract clause for GFI requirements for inclusion in shipbuilding contracts. Part of that clause recognizes the government's responsibility for an equitable adjustment to the contract for actions regarding changes in GFI delivery dates.

SCA COMMENT:

(5) The philosophy implicit in this reply is objectionable. The builder should be responsible for estimating cost of doing known required work. He should be risk free in the area of estimating the unknown - the buyer not the builder specifies the product. No matter what Navy says, the process if iteration of cost analysis inherent in complying with P.L. 87-653 as now done forces out of the estimate any cost provision for solving this unknown (in fixed price type contracts). In effect the resulting "reasonable balance of risk" is thus fixed at Navy-0, builder 100 - pending "claim" and claim resolution.

(6,7) These replies do indicate that Navy is trying to upgrade the quality of GFI and formally to recognize that there are cost and schedule consequences stemming from inaccuracies. Whether this carries on to reasonable attitude in pricing the cost of correction remains unknown but doubted.

NAVY COMMENT	SCA COMMENT
(8) "Ensure that QA requirements are compatible with primary specifications" (9) "Minimize redundant QA standards" (10) "Administer QA programs with professional judgment and reasonableness" (11) "Accept full cost responsibility for introduction of new QA inspection techniques during construction cycle" (12) "Limit QA actions to requirements of contractual agreement"	(8 - 12) Inclusive. Both this reply and the recent formal invitation to explore with NAVSEA the desirability of "interpreting for shipbuilding" the requirements of MIL-Q-9858 suggest that the Navy is awakening to the many inappropriate actions taken by its field inspectors in the name of quality assurance. Almost surely, however, this attitude does not extend to the nuclear field.

There are a number of actions recently completed and in the planning stage to improve the overall QA program. Actions recently completed include:

(i) A review of the diversity of interpretations of quality requirements for shipbuilding/ship repair application that seemed to be causing difficulty among the shipbuilding and Supervisor of Shipbuilding (SUPSHIP) community. Since this review, extensive meetings were held with the Shipbuilding Council which provided a standard interpretation of quality requirements for shipbuilding and ship repair which could be specified in the request for proposal and contract.

(ii) An assessment of the total training needs of the SUPSHIP Quality Assurance organizations. SUPSHIP Quality Assurance personnel have recently attended training courses conducted by NAVSEA and FLTAC Training Center in the areas of MIL-I-45208A application and Procurement Quality Assurance. However, because of the severe constraints placed on SUPSHIPS by the Congress budgetary cuts, the SUPSHIPS training plans have been curtailed or ceased.

Actions planned for FY 77 include:

(i) Continue to conduct reviews of SUPSHIP quality assurance programs both new construction and repair and alteration, to determine variations in resources, methods and procedures, quality assurance techniques and organizational approaches to quality.

(ii) Initiate efforts to standardize quality requirements, where feasible, by type of ship and/or design configuration.

NAVY COMMENT	SCA COMMENT
Upon completion of all the actions planned and underway, it is expected that the following will be able to be accomplished:	
(i) Make necessary changes to ensure optimum quality assurance organizations and staffing patterns for SUPSHIP subject to budgeting constraints.	
(ii) Establish a total training program for SUPSHIP personnel again subject to budgetary constraints.	
(iii) Standardize, as appropriate, quality assurance requirements.	
(iv) Provide uniform interpretation of quality requirements for shipbuilding/ship repair application.	
The question of attitude, however, is not one-sided on the part of government agents. Regrettably, too often the attitude of the contractor's personnel is not "are we providing what the specifications require" but "what is the absolute minimum we can get by with providing." Because of this, government personnel responsible for monitoring the contractor's quality and performance, become "doubters" expecting negative performance by the contractor. Every effort must be made by both sides to establish mutual understanding and trust.	Considerable validity attends this assertion. On the other hand, there is much less attention to preventing "getting away with it" in the commercial field and the commercial ships seem to stand up.

EXHIBIT B.2

SUMMARIES OF TWENTY

SIGNIFICANT STUDIES ON

ACQUISITION PROCEDURES

1939 - 1977

1. REPORT OF BUREAU OF SUPPLIES AND ACCOUNTS TO SECRETARY OF THE NAVY

Subject: Cost of Naval Ships

Date: 21 September 1939

The study was initiated by SECNAV "to answer the repeated question from members of Congress and others: Why do Naval vessels cost so much?". The subject was analyzed by partial attention to the following questions:

Why do Naval ships cost so much?

How do present day costs compare with former costs?

What do the costs represent?

How can costs be controlled?

The study reviewed the history of naval construction and factors of national policy from 1890 to 1939. Standards of comparison and influences on cost were listed. Comparative costs of construction were given for battleships, cruisers, destroyers, submarines, aircraft carriers and auxiliaries for three periods of construction activity. Cost data consisted of total cost per ship, cost per horsepower, and cost per ton. The study also indicated that influences of national policy, competition and capacity of the industry, and the impact of labor and legislative changes have an effect on Naval ship costs. A short narrative and some foreign costs were provided to supplement cost data in a general way.

A brief comparison of cost factors in Navy yards versus private yards was made, but it was not quantitative. It should be noted that the Merchant Marine Act of 1936 authorizes the construction of merchant ships in Naval Shipyards if commercial facilities are unavailable or if prices are not reasonable. The study, however, considered Navy shipyard costs are of doubtful value in lowering prices paid for ships in private yards.

Adjustments to contracts for inflation and profit were noted, and a suggestion was made that cost plus fixed fee contracts with an incentive clause, would be the best way for Navy to contract for ships.

Conclusions

- Cost of Naval ships increased because of technological progress, i.e., increased horsepower and improved materials.
- Cost of ships increased due to inflation in the economy.
- Costs are relative only for similar ships built in the same approximate period.
- Complete knowledge of current labor and material prices and production methods in detailed items is needed for determining reasonable costs.
- More effort must be taken to assure reasonableness of estimates and in holding to them during production.
- When contracts are negotiated the costs should be carefully investigated and a detailed knowledge of approximate costs obtained.

2. REPORT OF STUDY BY CHIEF OF NAVAL OPERATIONS
(Holloway Report)

Subject: New Construction Costs of Major Warships

Date: December 1, 1967

The study was authorized in October 1967 to determine the causes of rising costs of naval ships. From a large amount of cost and narrative material, three warships in the 1967 program were selected for review, namely, CVAN, DLGN, and SSN. Costs were compared using current estimates for these ships, costs of similar completed ships, and costs of the similar completed ships under current economic conditions.

The original estimate for CVAN 68 computed in 1964 was compared to the current estimate of 1967. Navy procurement practices and a ten year history of ten weapons systems were also included in the report.

Conclusions

On the ships as a group, cost differences (increases) were attributable to:

1. Inflation (material and labor)
2. Specification changes
3. Design differences (nuclear propulsion; other principal items)
4. Change order differentials
5. Accounting changes
6. ILS (Integrated Logistics Support)

From 1958-1967 the average cost of ships increased by 6.6 percent per year, but on the CVAN it increased by an average of 8.4 percent for three years (1964-1967), which is roughly the same as annual cost increases for all ship types over the corresponding period. This was due to a higher increment of inflation in the latter years.

Savings in shipbuilding costs could be achieved through:

1. Learning curves which were in effect at the time
2. Elimination of design changes
3. Multi-ship and multi-year procurement
4. Concept formulation and project definition

A true cost comparison is an extremely complex process. There are no models which can satisfy the requirements of analysis completely.

Estimating by NAVSHIPS is relatively simple and gives satisfactory results for NAVSHIPS' requirements. But, it is limited by format and output and is not adequate to provide cost data either in variety or detail to promptly respond to valid requirements of naval activities having need for this information for parametric studies or operational analysis. There must be a focal point for all costs and it must be staffed and facilitated.

3. REPORT OF THE NAVSHIPS PROCUREMENT REVIEW GROUP

(Sanders Scanlon Report)

Subject: An Evaluation of the Effectiveness of the Ship Procurement Process

Date: 30 January 1969

Since the effectiveness of NAVSHIPS procurement was being questioned by outside authority, this study was initiated to analyze every aspect of the procurement process for effectiveness. Command needs were identified and it was determined by detailed review whether the process met them. The focus was on ships, as the largest system. It was assumed that more compliance with ASPR, OSD, and Navy policies was not necessarily a good test for effectiveness.

The Review Group established 43 recommendations for improvements in the procurement process under the following five major categories:

- Ship Procurement Effectiveness (11 recommendations)
- Financial Management Process (7 recommendations)
- Technical Development Process (2 recommendations)
- Evaluation of Procurement Actions (16 recommendations)
- Achievement of Procurement Management Objective (7 recommendations)

Four major measures, namely cost control, milestone achievement, ship performance and standardization, were used in developing the recommendations. Principal conclusions were:

Cost Control

Eleven completed ships with cost records were used for the review. Values for factors which influence cost variances were listed. Variances offset to a considerable degree. Effectiveness of control depends on the criterion used. Using a $\pm$ 3.7% cost variance on DLGN 35 as a base, eight of ten other ships in the sample indicate inadequate cost control, although the average 11 ship variance was only (-) 2.9%. On an "absolute" basis, seven of the 11 ships met the objectives because the costs were below budget estimates.

The report indicates that the small total decrease of the 11 sample ships would indicate that NAVSHIPS planning and cost estimating for ships needs no improvement. However, when individual ship costs are analyzed, it indicates that NAVSHIPS must expend an unusually large part of its efforts trying to control a fluid cost situation.

The variance by cost categories for the 11 ships showed that changes initiated by NAVSHIPS and others generated the largest increases, while the variances for the basic construction and GFM resulted in significant decreases.

Milestone Achievement

Milestones were changed so frequently that they become essentially uncontrolled events. Planning is based on optimum conditions that seldom prevail. Ship delivery variance for 39 ships averaged 10.4 months delay, which had adverse cost effects on several accounts. Twelve major causes of delay were identified with a breakdown of percentage magnitude.

Planned delivery date is the most important milestone and, in most cases, it is not achieved.

Ship Performance

Ship costs are affected by deficiencies and time it takes to correct them. To the extent that they are Navy responsibility (GFM, GFE, specifications, etc.), milestones and estimates are adversely impacted. Navy improvement is needed as 42% of deficiencies at final trials were Navy responsibility.

Standardization

Lack of standardization increases the costs of ships. It does not exist to the desired degree on Navy ships, and little progress has been achieved to improve the matter.

Cost Estimating

In a detailed treatise of the Financial Management Process, a section is devoted to effectiveness of cost estimating, pp. 125-135. The following adverse elements can be considered as problems:

- Characteristics and cost data are not readily available for new ship concepts.
- Changes in design may go beyond estimates and future characteristic funds.
- Changes in specifications and GFM during construction may go beyond estimated budget.
- GFM list is not firm nor priced out for budget purposes.
- Changes in political/economic conditions are difficult to forecast and budgets frequently missed their mark on this point.
- If budgets anticipated construction in private yards, but subsequent decision required construction in naval shipyard, the end-cost budget price is too low.

Several of the recommendations were directly related to ship acquisition cost estimating. These are:

Recommendation Number	
III-6	That NAVSHIPS clarify the relationship between SHIPS 05F and SHAPMs to provide greater SHAPM control of ship budget estimates and preliminary procurement plans.

Recommendation Number	
IV-2	That the existing end cost funding policy for ship construction be modified to provide for supplementary funding to cover cost growth resulting from an economic growth rate greater than that predicted and other factors beyond Navy control.
IV-3	That action be taken to improve the compatibility between cost estimates cited in basic programming documents (such as the FYDP and NPO), and those used for budget submissions. Until this is accomplished, NAVSHIPS must maintain a continuing external relations program to improve our cost estimating image at higher levels of command.
IV-4	That a formal procedure be developed jointly by NAVSHIPS and OPNAV to secure timely redefinition of a proposed ship in cases where NAVSHIPS cost estimates are modified during the budget process by higher authority without a compensating change in ship description.
IV-5	That ship construction financial records and reports now maintained separately by SHIPS 02, 05, 10 and SHAPMs be systemized to provide a central data source independent of SHIPS 05F and readily accessible to other elements of the Command for periodic Command appraisal, studies and general information of all concerned.

4. REPORT OF CENTER FOR NAVAL ANALYSES TO DIRECTOR, SCN PRICING AND COST CONTROL STUDY

Subject: Study of Economic Factors Applicable to Shipbuilding

Date: 10 February, 1969

Purpose of the study was to measure the influence of economic forecasts of prices and market conditions from 1961-1967 on Navy's fiscal problems. Questions to be answered were:

- What is difference between budget estimate forecasts and current estimates?
- Which portion of difference is attributable to forecasts?
- Should estimators be responsible for economic forecasts, or should a higher authority do them?
- What other aspects of the problem require management attention and decision?

Conclusions

- Based on absolute differences there was a variance of 13.7%-20.6% between original budget estimates and current estimates during individual years of the 1961-1967 period, but because of the mix of overestimates and underestimates the net difference was only 2.3% for the entire period.
- Forecasting errors alone varied between 0.8% - 6.2% during individual years, for a net average of 2.4% for the entire period. It appears that the net forecasting error is nominally equal to the entire net difference in the estimates, but the comparison is misleading, as several other factors are involved.

- There is no compelling reason for locating forecasts at a higher level. The estimating office, 05F, has more information on the shipbuilding industry than any other place in government. There is no reason to expect an improvement in forecasts at a more authoritative level, major errors made in 05F were also made by other professional price forecasters in the same period.

Suggestions for Ship Cost Estimating

- The addition or assignment of a staff member whose full-time job would be concerned with price forecasting and with prediction of market conditions in shipbuilding and related industries.

- The use of this individual as liaison with groups in the government, industry, and the universities that are engaged in construction of indices, the economic study of industrial organization, and economic forecasting, and to get consulting help from them as needed.

- The use of such consulting help to set up an explicit system that would allow the cost estimating group to see how well it was doing and to display to others in DOD what it was doing.

Such suggestions do not provide promise of vast cost improvements, but they would promote an increase in credibility and documentation of the SCN ship estimating process.

The study included analyses of several other causes of cost differences between budget and current estimates, such as change in specifications, insufficient design data and changes in design data, escalation, etc. Appendix A notes the nature and problems of indices; Appendix B is a treatise on productivity; Appendix C deals with escalation computations. The appendices mentioned above refer to the CNA Study per se and are not included in this Appendix.

5. SCN PRICING AND COST CONTROL STUDY

Subject: Chief, Naval Material SCN (Shipbuilding and Conversion, Navy) Pricing and Cost Control Study

Date: April 1, 1969

The SCN (Shipbuilding and Conversion, Navy) Pricing and Cost Control Study was initiated 8 August 1968 by the Chief, Naval Material as a result of evidence that the SCN appropriation would incur a deficiency if the Navy was to continue its plan to build and convert all the ships then in its authorized program. It was staffed by Department of Navy personnel. The study commission was:

> "Objective. To identify and describe those improvements and modifications to existing shipbuilding and conversion management systems, including organizational relationships, which, when implemented, will seek to ensure that all programmed new Navy ships can be acquired and all programmed conversions accomplished within funds provided in the SCN appropriation. To this end, the management system must include provision for the development and maintenance of valid estimates for programmed ships and effective means of controlling costs within the total limit of the SCN appropriation."

The study identified two major time-related groupings of events during which important decisions affecting SCN program control were made. These were:

The planning and pricing period

The cost control period

FINDINGS AND CONCLUSIONS

The major causes for the current funding deficiency in the SCN program are found traceable to the following, all of which contributed in varying degrees to the total result:

- Inadequate planning for the early, firm definition of ships.
- Funding of developmental systems and experimental ships under SCN.
- Reducing budget prices of ships below those developed by professional ship cost estimators.
- Inadequacy of specifications, control of change orders, and early anticipation of claims.
- Lack of adequate management information and cost control systems for Ship Acquisition Project Managers (SHAPM).
- Unsuccessful control of naval shipyard new construction and conversion work.
- Failure always to balance program decisions with their cost impacts.
- Shortages of manpower at NAVSHIPS Headquarters and other SCN management support activities.
- Inability to forecast accurately for two to five years economic conditions in the shipbuilding industry.
- Reprogramming of apparent excess funds to offset new program requirements.

RECOMMENDATIONS

The study submitted 83 recommendations, which when implemented are intended to improve the ability of the Navy to maintain fiscal control of the program. The list of recommendations covered:

- Continuation of end-costing
- Policy coherence
- Control of concurrent development project
- Stability and depth of planning
- Estimating capability
- Economic factors
- Pricing practices
- Strengthening ship acquisition managers program and cost management
- Improved SCN management information system
- Control of specifications, change orders and material
- Disciplined decision making and configuration management
- Expanded use of concept formulation/contract definition
- Improved management of ship construction and conversions at naval shipyards
- Balancing of personnel resources to need
- Implementation plan

A number of the recommendations relate either directly or indirectly to ship acquistion estimating techniques. These are (number identifies recommendation in SCN Report):

CHAPTER IV.C Control Of Concurrent Development Projects

IV.C-2 NAVSHIPS ensure that estimates covering developmental systems or equipments included in the characteristics for a ship are realistically based on statistical analyses of cost growth and cost impact developed from past concurrency decisions. In addition, designs and plans for such ships should include a fall-back position which would permit continuation of construction in the event the development item fails to meet its cost, schedule or performance objectives.

CHAPTER IV.D Stability And Depth Of Planning

IV.D-2 OPNAV, in planning for Program Objectives, give sufficient emphasis to the second year of the plan and attempt to define it adequately to permit the development of at least class "D" (Feasibility Estimate) estimates for that year. For the out years, studies sufficient only to develop class "F" (Ball Park) estimates should be performed.

IV.D-4 OPNAV provide Single Sheet Characteristics for new construction projects 21 months before the start of their program year; 27 months for multi-ship or complex conversions.

IV.D-5 OPNAV provide Approved Characteristics for new construction projects 15 months before the start of their program year; 18 months for multi-ship or complex conversions.

IV.D-6 The CNO defer any ship, except those undergoing full CF/CD, for which Approved Characteristics are not established 15 months (18 months for multi-ship and complex conversions) before the start of its program year.

IV.D-9 NAVSHIPS ensure that Ship Acquisition Plans are initiated 18 months before the start of the program year for new construction projects, 24 months for conversion projects.

CHAPTER IV.E Estimating Capability

IV.E-1 OPNAV require that estimates submitted to higher Navy levels during the decision-making process be categorized, by an appropriate classification system, to indicate the level of information or other direction available to the cost estimator at the time the estimate was prepared. (This has been implemented by OPNAVINST 7720.2 of 8 February 1969, which was developed by this study.)

IV.E-2 NAVSHIPS develop a greater in-depth estimating capability by establishing a significantly greater data bank and obtaining more detailed cost information from commercial bidders and naval shipyards.

IV.E-3 NAVSHIPS augment its cost analysis staff and enhance its capability for initial cost analysis of data on hand and of the data to be obtained to improve the estimating of cost appropriate to feasibility studies, preliminary designs, and associated trade-off analyses.

IV.E-4 NAVSHIPS ensure that early adequate definition is obtained for all ships in the Fiscal Year 1970 program to permit assignment of class"C" estimates to the total program.

CHAPTER IV.F Economic Factors

IV.F-1 NAVSHIPS ensure that recognition is given to the fact that the use of a consistent formula for forecasting SCN escalation requirements will result in excesses in favorable years and deficiencies in unfavorable years. Accordingly, the reprogramming of excesses in favorable years should be weighed carefully against the risks of deficiencies in future years.

IV.F-2 NAVSHIPS prepare a confidential annual survey of conditions to be anticipated in the shipbuilding industry during the forthcoming and subsequent (budget) year. Among other objectives, the survey should specifically attempt to forecast economic factors such as labor and material escalation, profit margins, and productivity factors. The survey should include such additional items as availability of manpower, probabilities of schedule adherence and other conditions which would have bearing on program decisions.

IV.F-3 NAVSHIPS develop and NAVCOMPT recommend to OSD, prior to official submission of the budget, the percentage factors to be used for escalation in developing SCN estimates for the budget year. Agreements on these statistical factors should be reached as part of the general guidance memoranda and not be subject to revision during the detailed budget review. A similar approach should be used for other statistical factors used in SCN estimating such as percentages allowed for change orders and future characteristics changes and other growth factors.

CHAPTER IV.G Pricing Practices

IV.G-1 SECNAV issue a basic policy statement that will discourage the establishment of prices for SCN ships when such prices have not been supported by the official estimating process.

IV.G-2 OPNAV(SCB) thoroughly evaluate the long-range effect of deleting desirable characteristics from a ship before they are deleted to obtain an end-cost estimate that is within an arbitrary price ceiling. There should be reasonable assurance that they will not be reauthorized as a change during the construction period.

CHAPTER IV.J Control Of Specifications, Change Orders And Material

IV.J-3 NAVSHIPS require that, as an element of the shipbuilding contract or pre-award survey, shipbuilders provide network diagrams in sufficient detail to establish the time relationship of major GFM, GFI and CFM items in controlling ship progress.

CHAPTER IV.K Disciplined Decision-making And Configuration Management

IV.K-9 NAVSHIPS develop full Configuration Management and change control procedures for implementation immediately upon submission of Fiscal Year 1972 budget estimates to ensure that characteristics do not change without compensating decisions.

CHAPTER IV.N Balancing Of Personnel Resources To Needs

IV.N-1 CNM reprogram from the field approximately 700 civilian personnel spaces within the total personnel ceiling of 97,348 available to NAVSHIPS to meet currently identified added requirements for SHAPMs (400 increase); SUPSHIP (233 increase); related staff functions (35 increase); and to provide a balance (32) for requirements to be more specifically identified with the implementation of the Study's recommendations.

NOTE: Included in the studyis a recommendation for an increase of 12 cost estimators and cost analysts.

IV.N-2 CNM similarly adjust Headquarters ceilings of other supporting SYSCOMS to meet increased staffing requirements resulting from the improvements to the SCN management system.

ESTIMATING CAPABILITY

In the discussion on cost estimating it was stated that there was a widely held opinion that deficiencies in the estimating capability of NAVSHIPS might be the basic reason for the deficit status of the SCN appropriation pointed toward the necessity for an early examination of that function to determine existing deficiencies, associated problems and areas requiring improvement. The report leads to the conclusion that ship estimating is adequate in situations where ships are well defined.

An in-depth statistical analysis of NAVSHIPS estimates compared with industry at the time of bid and proposal evaluation showed that the NAVSHIPS estimates for the basic contract price (54 percent of total ship end cost) show an average deviation from bid prices of less than 4 percent (-2.9 percent for new construction to 3.6 percent for conversions) for the FY 64 to FY 68 programs. It is apparent that estimating is not an exact science, as evidenced by the wide disparity among bids submitted by contractors for the same bid package. It is apparent, also, that the NAVSHIPS estimating capability (at time of bid and proposal evaluation), on a program basis, has proved satisfactory as compared with industry performance.

6. BOOZ-ALLEN COST CONTROL STUDY

Subject: A Survey of Government and Industry Cost Estimating and Cost Control

Date: April 10, 1969

This study was undertaken at the request of the Chairman of the SCN Pricing and Cost Control Study. The objective was to provide a frame of reference within which cost estimating and cost control as practiced in the Navy Shipbuilding and Conversion Program (SCN) can be evaluated. The report describes practices and illustrative case studies based on the analysis of information acquired on programs conducted by the following activities, and the degree of relevance of these programs examined to the SCN Program:

- Naval Air Systems Command
- Naval Ordnance Systems Command
- Naval Facilities Engineering Command
- U. S. Army (Research and Development Programs)
- Federal Aviation Administration
- Bethlehem Steel Corporation, Sparrows Point Shipyard
- Two helicopter manufacturers

The report offered the following conclusions based on in-depth survey and anclysis conducted of the eight aforelisted Government and private organizations' cost estimating and control practices:

1. Level of technology is a key parameter in cost esimating and cost control of a project. Both the methods used and the achievable accuracy are strongly influenced by technical uncertainty and technological risk.

2. Project duration is a factor of lesser importance in explaining cost growth. Although longer duration projects tend to cover larger cost growth ranges, the duration itself does not cause the growth to a large extent.

3. Cost estimating is highly dependent upon:

   - Degree of definition and level of technology inherent in the end item

   - Data base representative of the end item in the environment in which it is to be produced

   - Size and quality of cost staff

   - Existence of independently determined estimates and knowledgeable reconciliation of differences

   - Influence of pricing

4. Cost control is highly dependent upon:

   - Accuracy in cost estimating

   - Frequency of estimated cost updates

   - Accuracy and timeliness of reports on accrued costs

   - Decision-making capability at critical milestones (i.e., points of committing large expenditures, points at which technical objectives are modified, or points when cost growths appear imminent).

5. Level of technology not only explains cost growth but also usually dictates contract form in cases where a contractor is involved with the Government and in cases where a governmental department commits itself (i.e., "contracts" with Congress).

In reviewing all the various government and industry programs, it was noted that the Navy's shipbuilding program covered the greatest spread of technological uncertainty and risk. In addition, industry, in general, applies more resources to the estimating process. The estimates by industry are developed from a detailed analysis of all elements with intensive quantity inputs from the technical organization, and price quotations are obtained from vendors for materials and components.

The study also shows the type of estimator varies with the level of technology. In the area of no technological uncertainty, the estimator appears to be engineering-oriented. A different kind of estimator is present in an organization in which technological uncertainty is experienced; the personnel used in these areas have statistical training in their background. In the areas of technological risk, it was observed that the decrease in emphasis upon practical engineering training was replaced by increasing emphasis upon statistics and operations research techniques.

7. BLUE RIBBON DEFENSE PANEL REPORTS

Subject: Organization and Management of the Defense Department

Date: 1 July 1970

The Blue Ribbon Defense Panel was appointed by the President and the Secretary of Defense in July 1969. It was given the broad charter to study, report and make recommendations on:

- The organization and management of the Department of Defense and its effects on Departments' overall mission performance.
- The Defense research and development efforts.
- The Defense procurement policies and practices, particularly as they relate to costs, time and quality.
- Such other matters as the Secretary may submit to it from time to time.

The report's recommendations are heavily oriented toward Department of Defense organization and responsibilities of the many military commands. The areas of recommendations broadly cover:

- Organization
- Management of material resources
- Management and procedures
- Management of personnel resources
- Other Management considerations
- Conflicts of interest

Chapter II, Management of Materiel Resources, indicates that military hardware development programs continue to be plagued by:

- Major cost growths or overruns
- Schedule slippages
- Failure in performance

The report concedes that special problems found to exist in the major weapons systems acquisition process generally are applicable to the acquisition of Navy ships. In addition, Navy ship procurement and construction suffer several unique problems such as:

- Only customer which buys from its suppliers the types of ships involved.

- Procurement process should reflect a concern for a sufficiently broad industrial base to provide competition.

- As a sole purchaser of Naval ships, there is no basis for comparison within the Department to gauge efficiency of procurement process, when compared with aircraft and missiles.

- Since ship procurement is more a construction that a production process, economies of scale are not as readily available as in other major weapon systems acquisition.

- Program reflects inadequate consideration in the requirement process for trade-off advantages of a larger number of ships of less individual capability as compared to fewer ships of maximum individual capability.

The Blue Ribbon Panel report has some limited findings on cost estimating, the highlights of which are:

- The accuracy of cost estimates for acquisition programs has been widely overrated. It should be axiomatic that one cannot place a price on any program containing any unknowns. The inherent limitations on cost estimation imposed by technological uncertainties cannot be completely overcome.

- Contractor eagerness to sell long-term acquisition programs influences low-side cost estimates.

- Contracting policies and procedures have a tendency to support the level of proposed cost estimates.

- Competitive pressures of concept/formulation/contract definition have led to over-optimistic cost estimates for acquisition and not permitted a hard look at inherent pricing uncertainties. Parametric cost estimating techniques offer the potential for improved planning of cost factors.

- The lack of cost data base information for prior programs limits the accuracy of cost predictions for current ones.

- Original cost estimates should be considered only as baselines and should be revised and updated across the system or equipment life cycle.

The Report also indicates critical industry issues as:

- Industry trends toward over-responsiveness to expressed DOD desires or requirements.

- Contractors fail to point out potential risks associated with inherent technical uncertainties of system and equipment development.

- Cost estimates tend to be over-optimistic and in some cases unwarranted buy-ins.

- Reliance on public and political influence to determine selection of contractors for award is too prevalent.

Conclusions

Significant conclusions from the Report that relate to cost estimating are:

- The management cost information needed within the Department and for visibility to Congress on major weapon systems acquisitions should be improved by recognizing the evolutionary nature of cost baseline estimates. Estimates should be reevaluated at each significant milestone of development.

- Increased use should be made of parametric costing techniques to improve the quality of original and subsequent estimates, and to help offset the difficulties of estimating the cost of unknowns.

- Specialist careers should be established for officers in such staff, technical and professional fields as research, development, intelligence, communications, automatic data processing, and procurement.

- The duration of assignments should be increased, and should be as responsive to the requirements of the job as to the career plan of the officer. Officers continued on assignment for these reasons should not be disadvantaged in opportunity for promotion.

- In technical assignments, the officer's replacement should be assigned to the job sufficiently in advance of his predecessor's departure to be ready to take over without loss of momentum when he leaves.

8. REPORT OF THE ASPR PRICING SUBCOMMITTEE

Subject: Review of Cost Estimating Techniques Within DOD

Date: 5 September 1970

By memorandum dated 28 October 1969 from the Director for Procurement Policy OASD (I&L), the ASPR Pricing Subcommittee was directed to determine how best to improve cost estimating within the DOD. Nine weapons systems were chosen to serve as a medium for discussion rather than as a review of that system per se. These were:

System	Service
LHA	Naval Ships Systems Command (now NAVSEA)
A - 7 (1)	Naval Air Systems Command
S - 3 (1)	Naval Air Systems Command
441A System	Air Force Systems Command Electronic Systems Division
777 Program	Air Force Systems Command Space and Missile Systems Office
F - 15	Air Force Systems Command Aeronautical Systems Division
SAM - D (2)	Army Missile Command
TOW (2)	Army Missile Command
TD 660 and CV 1548 Projects	Army Electronics Command

The several problems were evaluated by representatives from the various cognizant commands and hence represents their views. The Subcommittee recommendations were:

1. A policy that requires systematic and continuous cost estimate monitorship on each weapon system and major items extending from concept formulation through completion of the final contracted item in a program. This should include:

- Basic minimum documentation requirements.
- Serial numbering system for estimates .
- Basis of establishing confidence levels and a system for recording these levels.
- Responsibilities of personnel engaged in cost estimating both full and part time.
- Guidelines for (i) refining cost estimates to eventually include specific contract items, (ii) reconciling succeeding with prior estimates and (iii) reconciling proposed or actual contract amounts (including Government objectives, negotiated target amounts and final amounts) with prior estimates.
- Certificates of each estimate, other than Government Contract Negotiation Objective, by the person designated the "Cost Estimate Monitor".

2. The position of "Cost Estimate Monitor" be established in a staff organization of each major subordinate purchasing command (e.g., Army Missile Command, Naval Air System Command, Aeronautical Systems Division). Each

cost estimate, except the Government Contract Negotiation Objective, should be compiled under the supervision of the Cost Estimate Monitor using appropriate resources from within his own organization or other organizations with the ultimate estimate being approved by the Cost Estimate Monitor.

3. Specific contract pricing is a function distinct from Government cost estimating in that it is more associated with an adversary effort on contract estimates. However, we recommend that the Government's objective prepared for a negotiation be compared with the discrete Government contract estimates that have been developed and that a reconciliation be accomplished if the difference is not within the established acceptable tolerance limits. This reconciliation should be made a part of the contract approval documentation and the contract file. The preparation of independent Government cost estimates by procurement organizations should not be necessary since such independent estimates for determining the broad cost parameters of the contracted items can be obtained from estimates prepared under supervision of the Cost Estimate Monitor.

4. OASD (SA) should be designated to perform a technical advisor and monitor function for all Government cost estimates for major weapon system procurements. In support of this requirement, guidance material, sources and uses of data, and should perform field surveillance of individual weapons system estimates. As a part of the monitorship function OASD (SA) should establish procedural requirements related to:

- A basis for determining the appropriate confidence levels for cost estimates.

- Maintenance of data banks, including procedures for checking the validity of numbers in the data banks and providing for their exchange between DOD elements.

- Procedures for determining and documenting the unique program events associated with the costs, (i.e., industrial technique used, major modification, interruption to the production line, etc.).

- Reconciliation of actual or proposed costs with estimates where significant differences occur.

- Training of cost analysis, price analysis and engineering personnel in cost estimating techniques.

5. Detailed cost estimates of contract prices based on a scope of work the Government is unlikely to be able to fund should be avoided, in the interest of saving manpower. Similarly, where contract options for likely variation in program scope are included, emphasis should be placed on the results of parametric estimates tailored to the individual contractor rather than laborious detailed cost estimates in the typical cost element buildup which may have little meaning at the time the option is exercised.

6. In order to introduce greater discipline into cost estimating and avoid dependence on "quicky" estimates made with short suspense, higher headquarters should attempt (1) to define the quantity, performance and scheduled parameters for which an estimate is desired as precisely as possible and (2) to identify the potential variations in production rates, quantities, and desired

performance. The estimating organization should make not only "point" estimates but also estimates over the range of "likely" options.

Conclusions

The Naval Ship Systems Command's estimating techniques for the LHA program were used as the vehicle for discussing the Command's organization for cost estimating, data collection, methodology used, and use of data and methodology. Improvement efforts in the following areas were considered fruitful over the long haul:

- Better system definition
- Concurrency items (development of new subsystem technology concurrently with ship construction)
- More data needed from shipbuilders
- Number of ship budget estimates seem to be excessive
- Predicting future economic conditions in the shipbuilding industry.

9. REPORT FROM CENTER FOR NAVAL ANALYSES

Subject: A Study of Organization Problems in SCN Procurement System

Date: 21 September 1970

At the time of this study the SCN fiscal problem had been growing rapidly worse since its documentation by the SCN Pricing and Cost Control Study of April 1969. In 18 months it grew from \$0.7 billion to between \$1.7 billion and \$2.0 billion. The SCN Study listed ten major causes of overruns, but "organization" was not among them. CNA alleges that this is a basic cause of fiscal problems. The study describes the nature of the problems.

The study reviews steps in the procurement process on the basis of end cost estimate, management, deficits, and reasons for overruns. In discussing cost estimating it states that estimates are off the mark not so much by estimating inability, but rather a lack of design data and changes made to ships after estimates are made.

In examining particular causes of the SCN cost overruns, it was found that cost estimating accuracy has varied fairly consistently with ship types. However, over the years of end costing, the relative mix of ship categories in each SCN program has changed. In the early years (starting in FY 1961), ship categories producing cost underruns predominated, while in later years those producing cost overruns have predominated, thus causing the SCN account

to go from large surpluses to large deficits.

Cost estimates of less than budget quality are used in SCN budgest as ships were inadequately defined in scope and type. The basic characteristics of ships were not firmly established prior to inclusion of the ship in the budget submission. The paper emphasizes that a basic cause of the SCN fiscal problem, however, is the structure and the composition of the Navy SCN procurement system.

In structure, the procurement organization is subordinated to the command of OPNAV - a condition which biases the resolution of consumer (OPNAV) - producer (NAVMAT) conflicts of interest. At the same time, OPNAV assumes no accountability for cost problems resulting from the system.

In composition, the procurement organization is controlled by the military who allegedly disparage the importance of procurement, who rotate through billets so rapidly that they acquire only a superficial knowledge of procurement competence, and whose retirement system militates against Navy interests.

Conclusions

The paper suggests two alternative directions in which to seek solutions:

- Completely civilianize the procurement organization, keeping it within the Navy and reporting to the ASN(I&L), or

- Emphasize the accountability of military executive management for procurement, and offer incentives for successful performance.

Changes suggested in the paper include:

- Let Navy keep (or at least share in) cost savings, instead of having to give them up.

- Establish a uniformed, professional procurement class within Navy.

- Modify rotation policies so that procurement officers stay within their specialty.

- Modify retirement policies so that procurement officers are not forced or encouraged to retire at the peak of their professional competence.

These solutions are only outlined in the paper, with little suggestion for deciding which is the better. Further, the paper emphasizes that SCN procurement problems are only a part of the larger weapons procurement complex, and that solutions should be focused on the larger issues rather than the separate parts. The paper, then, describes a problem, indicates possible directions for solutions, and suggests areas for further study.

10. REPORT OF CHIEF OF NAVAL MATERIAL

Subject: Command Inspection of Naval Sea Systems Command Headquarters

Date: 10 June, 1971 (Principal Report) and supplements in 1972

The purpose of the inspection was to examine the functions of all departments to determine their effectiveness within their own units and as interrelated to other units in the CNM command. It was intended to perform these inspections periodically.

Conclusions

Four conclusions were made in regard to Financial Management, Code 01, in relation to the Cost Estimating Branch. These were:

- June 25, 1971 -- a training plan for cost analysis and cost estimating should be established to strengthen capabilities. (It was reported complete.) A "TAR" manual should be prepared.
- March 15, 1972 -- establish a plan to interface with and assist contract negotiators in understanding outputs of the estimating division, as the negotiators had limited estimating capability. (This was reported in final review.)
- May 18, 1972 -- establish procedures for ship life cycle costing. (This was reported complete.)
- August 21, 1972 -- develop cost and feasibility studies for Ships 04 on a priority basis. (Comment was that lack of personnel and a greater workload would not permit this service.)

11. SHIPBUILDING AND CONVERSION IMPROVEMENT PROGRAM (SCIP) REPORT ON EVALUATION STUDY

Subject: Report on Evaluation of Shipbuilding and Conversion Improvement Program (SCIP)

Date: July 1972

The Shipbuilding and Conversion Improvement Program (SCIP) was aimed at implementing the recommendations of the SCN Pricing and Cost Control Study, April 1969 together with other known management actions. The SCIP was established on 15 January 1970. The program emcompasses more than 154 individual improvement tasks identified over a three year period, including 83 recommendations in the 1969 SCN study. The subject SCIP Evaluation Report covering a three year operation of SCIP states that of the 154 items, 97 are completed, 25 have been consolidated into other related items, and 32 are being worked on, 17 of which are on plan and 15 behind plan. The complete implementation was not scheduled to be finalized until after July 1973.

The planned and actual improvement results covered under the SCIP program are grouped as follows:

- Organization and staffing
- Planning
- Estimating
- Budgeting
- Financial control system

- Specifications
- Change control/configuration management
- Contractual provisions
- Risk management
- Management information

The evaluation report of SCIP indicated notable progress had been made in correcting some management weaknesses identified in the 1969 SCN study. There continue to be problems which SCIP has not resolved, certain of which were either not present or not apparent at the start of SCIP, while others are of a continuing nature.

Conclusions

The following were the conclusions in the sections discussing cost estimating and continuing problems:

- Ship cost estimating is not an exact science but Navy estimators continue to demonstrate satisfactory capability to anticipate industry bids. For the fiscal years 1964-1971, the Navy technique was able to predict the industry "average bid" within three percent for new construction and one percent for conversions.

- Using similar detailed information, ship cost estimates provide reasonably accurate ship cost budget estimates, since techniques and methodologies for both are the same.

- The ships cost estimate classification system, which reflects the quality of information furnished to professional ship cost estimators, is a significant improvement in the management of the SCN program, both as a needed communication medium to higher level authorities and as a motivation device for the

early development of essential information needed for the development of accurate cost estimates.

- There is, however, a steady departure from the OPNAV required schedule for the issuance of ship characteristics and instability of the planned programs.

- The trend in the late receipt of ship characteristics is considered to be a large contributor to the deterioration in the quality of ship cost estimates. This is also contributing to delays in the development of feasibility estimates and completion of necessary design trade-off studies.

- The development of Class "C", budget quality estimates is not compatible with the late receipt of characteristics.

Recommendations

The evaluation report lists 23 recommendations of which the following are pertinent to or impact on the cost estimating function of NAVSEA:

Number	Recommendations
5-3	OPNAV issue a policy that deviations in CNO SCN management policy, such as authorizing changes in characteristics without compensation or without Future Characteristic Changes (FCC) funding, are authorized only by CNO/VCNO.
5-4	NAVSHIPS include a factor in ship cost estimates to establish reserves for contingencies for claims and risks inherent in shipbuilding contracts.
5-6	NAVSHIPS, as part of the annual SCIP evaluation, provide analysis of SCN cost variances to CNM/CNO.
5-7	NAVSHIPS develop relationships between manpower deficiencies and SCN program problems to provide positive justification and support for manpower deficiencies.
5-8	NAVSHIPS submit a plan for increasing SCN management areas based on the personnel requirements determined through the effort in recommendation 5-7.
5-10	NAVSHIPS re-evaluate the factors in estimates to cover project manager growth. (see Rec. 5-4)
5-11	NAVCOMPT take action to obtain OSD approval that ships requiring in excess of five years to complete continue to be budgeted on an end cost basis, consistent with full funding principles. However, at the time of the annual budget representing the sixth year, an estimate must be prepared on the estimated obligation status as of the end of the fifth year. The estimated unobligated balance should be offered for rescission to the Congress and reappropriation requested to complete the applicable ship programs.

Number	Recommendations
5-12	NAVSHIPS require that escalation continue to be budgeted within the end cost of the ships with update as necessary each year with submission of the new budget.
5-13	NAVMAT through the NMC Shipbuilding Council evaluate previous end cost policy dealing with the management of the SCN account and ascertain if it is compatible with current SCN budgeting procedures and, if not, recommend changes which may be needed.
5-14	OPNAV provide the guidance and enforcement required to comply with the time-frame for development of ship characteristics specified in OPNAVINST 4700.12C of 20 Apr.'70.
5-15	OPNAV, in planning for Program Objectives, give sufficient emphasis to the current year of the plan to ensure a Class "C" (Budget Quality) estimate.
5-16	NAVSHIPS advise CNM/CNO whenever schedules for receipt of ship characteristics are not met.
5-17	NAVSHIPS extend the use of Class "D" classification to estimates whenever time factors inhibit confidence in estimates.
5-18	NAVSHIPS include, throughout the budget process, a 20 percent mandatory contingency allowance to estimate until a Class "C" estimate is attained.

12. GAO REPORT TO CONGRESS

Subject: Acquisition of Major Weapon Systems - Department of Defense

Date: July 17, 1972

This is one of a continuing series of reports on acquisition of major weapon systems and what further improvements can be affected in the process. The data in the report are distilled from studies of some aspect of 78 separate weapon systems. The following Recommendations or Suggestions were made to the Secretary of Defense:

- Emphasize (a) a continuing rigorous analysis of the need for new weapon systems, (b) a careful analysis of the impact of proposed needs on the manpower and dollar resources of the total defense force as well as the implication to the plans for the usefulness of the equipment already in inventory, and (c) the inclusion throughout of a properly structured process which makes tradeoffs between various ways of fulfilling a function.

- Reexamine the weapon systems which have been selected for project management and which have been retained under project management and spell out specifically, on a case-by-case basis, the functions that a project manager will, and will not, perform.

- Develop and implement DOD-wide guidance for consistent and effective cost estimating procedures and practices, particularly (a) an adequate data base of readily retrievable cost data, (b) a uniform treatment of inflation (c) an effective independent review of cost estimates, (d) more complete documentation of cost estimates, and (e) dependable program definitions.

- Develop and implement DOD-wide guidance to provide that (a) appropriate testing and evaluation be completed prior to making key decisions and (b) adequate controls be set over the granting of any waivers from required testing and evaluation.

- Reassess the criteria for designating weapon systems for selected acquisition reporting in an effort to expand the system.

The report comments on cost estimating for major acquisitions. It states that previous GAO reports have shown estimates are frequently understated for a number of reasons. The two overriding factors influencing the quality of cost estimates are the lack of completeness of a plan stating what should be done and inadequate documentation on what was done and how and why it was done. These factors and others relating to effective cost estimating procedures and practices are included in the aforementioned recommendations and suggestions to the Secretary of Defense.

In the DOD response letter of 15 May 1972, the Director of Defense Research and Engineering states:

> "In the area of improved cost estimating the Secretary of Defense, in December 1971, asked each of the Services to make independent cost estimates, in addition to other appropriate cost analyses, on major weapon systems at each key decision point and to make these estimates available for DSARC reviews. This action was followed in January 1972 with the establishment, within OSD, of a Cost Analysis Improvement Group (CAIG) to review the Service estimates and to develop uniform criteria to be used by all DOD units making such cost estimates. Under the CAIG's leadership, policies and procedures are also being developed to provide a retrievable and well-documented data base upon which more accurate cost estimates can be made."

13. REPORT TO THE CONGRESS FROM THE COMPTROLLER GENERAL OF THE UNITED STATES

Subject: Theory And Practice of Cost Estimating For Major Acquisitions

Date: July 24, 1972

The purpose of the study was to identify factors in cost estimating, by all services within DOD, which caused large increases on 47 weapon systems, and to offer suggestions on how the problem might be solved or abated. An average of 43 percent of cost growth was attributed to estimating changes between initial planning estimates and current estimates.

GAO selected seven systems in Army, three in Navy, and eight in Air Force as the samples to investigate. An evaluation of estimates was made on the basis of reviews of definition, availability of data, recognition of inflation and risk, etc.

Conclusions

Many problems were found which stemmed from an absence of specific direction on all management levels. Examples of findings are:

- No uniform guidance for cost estimating existed throughout the services.
- Each service had its own guidance of a varying nature, and it was often ignored.
- Cost estimating was done by reviewing previous estimates. This required accurate documentation. In virtually every reviewed case, the documentation was inaccurate or lacking.
- Data banks were sometimes lacking.

- There was no organized effort to gather cost information.
- Inflation was not treated uniformly.
- Known costs were excluded at times.
- Estimates tended to be low; therefore, a bias of advocates of weapons systems was suspected.

Recommendations

DOD must have a disciplined approach to cost estimating per a written plan. A consistent guidance must be developed for all services. Specifically it should include requirements for:

- Data bases that are readily retrievable
- Treatment of inflation
- Complete documentation of estimates
- Feedback of cost results to compare to estimates
- An independent review of estimates

(DOD subsequently advised that it plans to provide this guidance and that all services had taken steps to improve their capability.)

14. REPORT OF THE COMMISSION ON GOVERNMENT PROCUREMENT

Subject: Report of the Commission on Government Procurement

Date: December 1972

The Commission on Government Procurement was created by Public Law 91-129 in November 1969 to study and recommend to Congress methods "to promote the economy, efficiency and effectiveness" of procurement by the executive branch of the Federal Government. The report covered the entire range of U.S. Government involved with industry.

Because the Report is based on an integrated view the acquisition process, the recommendations are linked to form a structure that is applicable for acquisition progress of all agencies. Recommendations are not designed to be applied selectively to improve parts of the acquisition process, but rather to work together to control the whole. The Report covers the following areas of government procurement:

- General Procurement Considerations
- Acquisition of Research and Development
- Acquisition of Major Systems
- Acquisition of Commercial Products
- Acquisition of Construction and Architect-Engineer Services
- Federal Grant Type Assistance Programs
- Legal and Administrative Remedies
- Selected Issues of Liability: Government Property and Catastrophic Accidents
- Patents, Technical Data, and Copyrights
- Other Statutory Considerations

A series of recommendations covering this wide range of subjects were developed. Volume Two, Part C (of four volumes) deals with the Acquisition of Major Systems. The proposed list of recommendations are:

- Establishing Needs and Goals

  - Start new system requisition programs with agency head statements of needs and goals that have reconciled with overall agency capabilities and resources.

  - Begin congressional budget proceedings with an annual review by the appropriate committees of agency missions, capabilities, deficiencies, and the needs and goal for new acquisition programs as a basis for reviewing agency budgets.

- Exploring Alternate Systems

  - Support the general fields of knowledge that are related to an agency's assigned responsibilities by funding private sector sources and the government in-house technical centers.

  - Create alternative system candidate.

  - Finance the exploration of alternative systems.

  - Maintain competition between contractors exploring alternative systems.

- Choosing a Preferred System

  - Limit premature system commitments and retain the benefit of system-level competition with an agency head decision to conduct competitive demonstration of candidate systems.

  - Obtain agency head approval if any agency component determines that it should concentrate development resources on a single system without funding exploration of competitive system candidates.

- System Implementation

  - Withhold agency head approach and congressional commitment for full production and use of new systems until the need has been reconfirmed and the system performance has been tested and evaluated in an environment that closely approximates the expected operational conditions.

- Use contracting as an important tool of system acquisition, not as a substitute for management of acquisition programs.

- Organization, Management and Personnel

    - Unify policymaking and monitoring responsibilities for major system acquisitions within each agency and agency component.

    - Delegate authority for all technical and program decisions to the operating agency components except for the key agency head decisions.

On the subject of "Cost Estimating and Funding" the Report indicates that improved estimating techniques will only bring about relatively small improvements in major cost increases. The report elaborates on this and reasons for avoidable cost growth are as follows:

> "Because of the repeated pattern of major cost increases in system acquisitions, many people have concluded that there is need for better cost estimating and better risk analysis. However, improved estimating techniques can bring only relatively small improvements. About 15 percent of cost growth in major programs during the 1960's can be attributed to the inherent imprecision of present cost estimating procedures. Better cost control will come only if fundamental changes are made in the way systems are refined and chosen early in the acquisition process; these steps largely determine ultimate cost and performance.
>
> Entire system costs cannot be estimated realistically during its early development. Institutional arrangements and advocacy pressures tend to drive cost estimates downward and to produce overly optimistic schedule and performance appraisals. All levels in a department , in industry, and even in Congress can become parties to the "selling" of programs founded on unrealistic and unattainable system cost goals. From observations made in earlier chapters, six principal reasons for avoidable cost increases can be cited:

- System advocacy and premature commitment. System selection occurs prior to consideration of competing alternative approaches, in order to obtain the funds necessary to proceed with the acquisition program. This choice occurs too early to identify uncertainties and to predict costs.

- Misuse of price competition. An intense, "winner-take-all" competition frequently occurs before a design is known to be a satisfactory solution to a need. Technical innovation in competing proposals is inhibited by a predetermined technical approach that makes the competition depend too heavily on the price one company proposes as compared to another. The winner is selected with little assurance that he can meet his quoted price. This form of competition encourages "buy-ins." Buy-ins are difficult to avoid. It is very awkward, for example, for a Government contracting official to counter a too-low offer with a much higher price.

- Overlapping development with production. Committing to extensive production when much development, test, evaluation, and redesign still remain to be done usually leads to major retrofit and modification costs. Components, equipment, and tools can be made obsolete by design changes as the development progresses. This practice, referred to as "concurrency," also causes buildups of large numbers of people at prime contractor and subcontractor levels to handle all aspects of the procurement. This early buildup usually comes before a system is ready for full-scale (final) development and major production.

- Demands for unachievable performance. Attempts to achieve technical and performance requirements, not validated through early development efforts, often lead to unexpected technical difficulties and related cost increases. The technology base may not be adequate or the required technical development cannot be accomplished within the scheduled time and cost limits. Further, when portions of the system's design originate from multiple industry and Government sources (transfused design requirements), no single organization undertaking system responsibility may have the technical knowledge needed to determine if the specified performance is achievable or if cost and schedule are compatible.

- Demands for increased performance within present technology. Demands for increased performance capabilities over previous systems have been a principal factor in the growth of new system costs. When new capabilities depend on squeezing more performance out of existing technology, the result usually is increased complexity and disproportionately high cost.

- Sole-source development. When a decision is made for a single system solution rather than to pursue competing approaches, the contractor selected at the outset becomes a sole-source developer and producer. Without the challenge of competitive alternatives, cost control is problematical and some complacency inevitably develops.

The Commission's Report concludes as follows on the subject of estimating:

- Some increase from an initial estimate for a major system is almost certain to occur:

  - Intrinsic errors of estimates can be traced to human fallibility and imperfect information and skills which cannot be avoided.

  - Optimism of Government and industry program advocates is inherent. Although optimism is essential to success, it should be compensated for in estimates.

  - The longer the time period covered by an estimate the more likely the estimate will be unrealistic. External forces can severely affect the cost of a system and should be included in the estimates. Because of inflation and a high degree of technical uncertainty an estimate will invariably be too low.

- Decisions to propose a major system program for Congressional approval have often been made before high-risk system features have been resolved and before realistic cost estimates can be made, leading to cost growth.

- Major systems are entering the final development and production phases at costs so much in excess of planned amounts that force levels are being substantially reduced.

- Efforts must be made to strengthen and increasingly use an agency's cost estimating capability. However, these efforts will not materially reduce the incidence of cost increases unless more basic changes are made in how systems are defined, competed, developed, and evaluated.

- To improve estimating and funding considerations, a candidate system should not be selected until alternative systems have been explored competitively within an approved cost goal for the need, and until uncertainties have been narrowed acceptably. Candidate systems should be carried in R&D accounts until one is selected for the final development.

15. DOD TO HOUSE COMMITTEE ON ARMED SERVICES

Subject: Study of Cost Escalation

Date: March 1973

The Department of Defense was requested by the Committee on Armed Services, House of Representatives (House Report No. 92-1149, pp. 8-9) to conduct an escalation analysis which the Committee could use to make whatever legislative changes might be required to better control contracting procedures.

The report covers the entire defense budget and programs in five major sections as follows:

- Defense Budget Trends and the Impact of Inflation
- Perspective of Cost Growth and Inflation
- Some Technical Aspects of Inflation Measurement
- Treatment of Inflation in Defense Budgets and Programs
- Treatment of Escalation in Defense Contracts

The highlights of the summary contained the following points.

The impact of inflation has been greatest by far in the area of pay and operating costs. Weapons costs have not been a dominant factor in the Defense budget trend, nor is weapons procurement the major source of inflationary problems. The inflationary impact upon other Federal agencies and upon state and local governments collectively has been even greater.

Long-run changes in unit costs are sometimes cited as evidence of runaway weapons costs. Such increases do not apply to Defense alone; they are likely to occur in any area where technology has brought major changes in products.

A series of spectacular charges have been made regarding "cost overrun" using planning estimates as a starting point which is inappropriate. Starting from the development estimate -- the point at which a significant portion of the total costs are committed -- cost growth is one-half of that alleged.

Cost growth is the net of all factors -- changes in quantity, design, schedule, inflation rates, and others. Some of these increases resulted from design or other changes, deliberately chosen. Others arose from failure to anticipate the extent of inflation, an especially easy mistake to make in preparing estimates in the 1960's.

Costs may vary from earlier estimates for a wide variety of reasons. This is true of budget estimates, which cover all the costs (often involving several contracts) to complete a given fiscal year program; of SAR estimates, covering many years; and it is true for individual contracts as well. For individual contracts, such changes can arise from:

- The hazards of any forecast of the labor and material required to perform a given job.
- Fluctuations in the contractor's business base, which may require significant shifts in his labor planning, changes in overhead rates, etc.

- Performance of subcontractors and suppliers.
- Strikes, fires, floods, etc.
- Increases in tax rates, utility rates, etc.

A second set of factors contributing to changes in costs derive from actions of the DOD, involving such matters as design and engineering changes, schedule changes, and provision of GFE.

And, third, there is the matter of escalation -- the impact of inflation on the costs of doing a particular job. This represents the result of movements in price and wage levels beyond the control of DOD or the contractor.

Escalation, then, is only one of many factors that contribute to cost differences measured from earlier estimates.

Escalation is a fact of life in virtually every contract, Defense or non-Defense, in that both parties to any contract are aware that the cost of labor and materials are likely to rise in the period ahead. Escalation is automatically covered in many DOD procurements, in that the bidders quote a fixed price for a given number of articles, and the award is made to the lowest responsible bidder. In such cases, DOD does not know -- and does not need to know -- what allowance the bidder may have made for escalation in his bid, nor how his experience compared with his expectations.

Escalation clauses cannot do several things. They cannot guarantee that a contractor will be provided the precise amount necessary to cover the impact of inflation upon his actual costs. Where escalation clauses are based upon indices, the indices will represent average movements for a segment of industry. Both parties must recognize that they are dealing with approximations which while not absolutely precise, are reasonably fair to both sides.

As the result of the study, DOD has uncovered no areas where legislative changes, or extensive changes in contractor accounting systems, are required.

16. SHIPBUILDERS COUNCIL OF AMERICA PAPER ON NAVY SHIPBUILDING

Subject: "A Discussion of Navy Shipbuilding Industry Business Relationships" (Ad Hoc Committee Report)

Date: 22 October 1974

The subject paper was prepared by the Shipbuilders Council of America (Ad Hoc Committee on Naval Shipbuilding Procurement Procedures), October 22, 1974 as a result of Congressional Hearings in July and August 1974. It endeavors to place the views of major U. S. shipbuilders into perspective on policies, practices and actions of the DOD and Navy which, it is stated, are simultaneously and needlessly -

- Inhibiting Navalship procurements
- Circumscribing the Naval ship construction industrial base
- Escalating shipbuilding costs beyond normal inflation
- Creating financial burden for the Navy as well as the shipbuilder

SCA recommends 39 corrective actions as seen from the standpoint of private shipbuilders (as listed Attachment B.1) which it considers to be within the purviews of the Defense and Navy Departments. These are summarized in the following broad problem areas:

- Improving overall buyer/seller relationship
- Definition of ship to be built

- Realism in pricing and scheduling

- Availability of Government Furnished Information (GFI) and Government Furnished Material (GFM)

- Recognition of cost impact of delays

- Relationship of change orders

- Proliferation of management information reporting systems

- Reasonableness of Quality Assurance (QA) requirements

- Role of Defense Contract Audit Agency (DCAA)

- Needless monitoring of contractor purchasing actions

In a letter of October 20, 1976 to Deputy Secretary of Defense W. P. Clements, Jr., the SCA references its 1974 paper and indicates that --

> "Of these 39 recommendations, we perceive only two have been accepted, that ten have been accommodated in part, and that there is no available sign of affirmative action on the remaining 27".

SCA, in evaluating the status of its 39 recommendations listed in Attachment B.1, indicates DOD action in the following categories:

- Accommodated (A)

- Not Accommodated (NA)

- Accommodated in Part (AIP)

- Accommodation unknown but largely doubted (AU)

Deputy Secretary Clements in his letter of January 18, 1977 responds to SCA and reviews his past efforts to improve the shipbuilder-Navy relationships. He expresses his disappointment to reach mutual agreement with the shipbuilders under Public Law 85-804 and further believes that both Navy and the shipbuilders did not try hard enough . He reiterates a number of suggestions for the shipbuilders which he had included in his April 29, 1976 statement to the Senate Armed Services Committee.

Attached to Secretary Clements letter was a direct response from the Navy on each of the 39 SCA recommendations. It indicates that while considerable progress towards alleviating the shipbuilders' problem has already taken place and will continue, complete compliance is not reasonable in a major ship acquisition program. Certain of the recommendations appear valid, while some are not susceptible to black or white solutions. Others would not be acceptable to Congress or follow recognized contracting procedures. Many of the recommendations involve matters which could be or are being adjusted through administration and procedural modifications.

The SCA recommendations represent the combined views of all its members, even though some are working more closely with Navy requirements than others. Hence, SCA indicates that Navy has not accommodated most of its recommendations. A typical example is compliance with DOD INST 7000.2, where three yards have

already qualified for a management reporting system while some other yards are in the process of complying.

Only three of the 39 SCA recommendations apply indirectly to NAVSEA estimating and budgeting functions and these are:

- Improve accuracy of definition of ship to be built
- Improve accuracy of forecasting probable costs
- Provide reasonably for known and unknown contingencies

Conclusions

The SCA recommendations represent a compendium of all the shipbuilders' views without giving emphasis or priority to the more critical items. Navy planning, contracting and administrative procedure problems are emphasized with only limited criticism of Navy estimating and budgeting methods. Agreements with the recommendations would materially lessen the shipbuilders' risks; however, some of the recommendations would not be acceptable to Congress or follow recognized contracting practices. Corrective measures to the extent feasible will improve Navy-shipbuilder relationships; however, the contracts should be fair to both parties while at the same time acknowledging that every contract entails some risks for both parties. The current status (May 1977) of NAVY action and SCA reaction with respect to the AD HOC COMMITTEE recommendations is found in Exhibit B.1 to this Appendix.

ATTACHMENT B.1

Problem Area: Improving Overall Buyer/Seller Relationship

(A) . continue progress payments on basis of physical progress

(AIP) . authorize interest cost of borrowed funds as allowable expense items

(AIP) . resolve outstanding claims quickly and take all steps to minimize future claims

(AIP) . pending affirmative action in cited problem areas, adopt some type of cost-reimbursement, assured fee, contract and if appropriate, restructure existing fixed price type contracts as cost type contracts

(AIP) . recognize that through Government action or inaction financial and performance risks are being imposed on contractor resulting in costs that exceed impact from inflation

Problem Area: Definition of Ship to be Built

(AIP) . recognize that primary specifications inherently contain errors and inconsistencies

(AIP) . provide for prompt corrective changes

(AU) . ensure that changes are essential and will minimally affect production schedules

(AU) . accelerate efforts to simplify primary and subordinate specifications

Problem Area: Realism in Pricing and Scheduling

(AIP) . improve accuracy of definition of ship to be built

(AU) . eliminate requirements of doubtful value and uncertain cost

(AU) . improve accuracy of forecasting probable costs

(AU) . provide reasonably for known and unknown contingencies

(AIP) . outlaw "auction type" bidding techniques as basis for contract negotiation

Problem Area: Availability of Government Furnished Information (GFI) and Government Furnished Material (GFM)

(AU) . improve accuracy of GFI

(AU) . recognize cost and production consequences of erroneous and incomplete GFI and delayed delivery of both GFI and GFM

(AIP) . issue change orders promptly to rectify delays, defects and omissions

Problem Area: Recognition of Cost Impact of Delays

(NA) . accept full cost responsibility for deficient specifications, GFI and GFM

(NA) . accept full cost responsibility for schedule and production delays caused by Government action or inaction

Problem Area: Relationship of Change Orders

(NA) . defer change in primary specifications until after delivery of ship

(NA) . if impossible, issue instructions for change early in construction cycle

(NA) . arrange for provisional pricing of change orders of obvious high dollar value

(NA) . finalize pricing of these major change orders with dispatch

(AIP) . issue change orders promptly to rectify effects of Government action or inaction

Problem Area: Proliferation of Management Information Reporting Systems

(A) . examine governmental organizational structure bearing on ship procurement and production

(NA) . rely on contractor informational systems to maximum practicable extent

(NA) . reduce government imposed reporting requirements

(NA) . eliminate superfluous and nonproductive requirements

Problem Area: Reasonableness of Quality Assurance (QA) Requirements

(AU) . ensure that QA requirements are compatible with primary specifications

(AU) . minimize redundant QA standards

(AU) . administer QA programs with professional judgment and reasonableness

(AU) . accept full cost responsibility for introduction of new QA inspection techniques during construction cycle

(AU) . limit QA actions to requirements of contractual agreement

Problem Area: Role of Defense Contract Audit Agency (DCAA)

(NA) . limit role of DCAA to financial accounting

(NA) . restrict DCAA activities to verification of contractor's cost and forecasts of costs

(NA) . consolidate DCAA functions and those of Navy Supervisor of Shipbuilding in contractors plant

Problem Area: Needless Monitoring of Contractor Purchasing Actions

(NA) . revive practice of reliance on approved contractor purchasing system

(NA) . eliminate review and prior approval of each proposed subcontract

(NA) . cancel NAVMAT Notice 4330, dated November 1973, titled "Surveillance of Sub-Contracting Operations"

17. REPORT OF THE NAVY MARINE CORPS ACQUISITION REVIEW COMMITTEE, JANUARY 1975 (VOLUMES I AND II)

Subject: To Assess the Organizations, Management, Staffing, and Procedures Used by the Navy in Developing and Producing Major Weapon Systems

Date: January 1975

The Navy and Marine Corps Acquisition Review Committee (NMARC) was established by the Secretary of the Navy in August 1974 to assess the organization, management, staffing, and procedures used by the Department of Navy in developing and producing major weapon systems. The study was chaired and conducted by civilian members selected from the highest management levels of U.S. industry in order to provide an independent unbiased report.

The NMARC examined and analyzed all major functions in the acquisition process. A number of recommendations were then made in each of the major functions including overview studies. The functions and number of recommendations are listed as follows:

Function	Number of Recommendations
Overview (OVRVW)	10 (pg. II-44)
Research and Development (R&D)	34 (pg. III-65)
Test and Evaluation (T&E)	20 (pg. IV-20)
Procurement (PROC)	51 (pg. V-50)
Production (PROD)	57 (pg. VI-77)
Cost estimating, budgeting and financial management (COST)	82 (pg. VII-121)
	254 Total

It was the opinion of the Committee that the acquisition process for surface ships offers the most significant potential for improvement. On this basis, the separate NMARC Shipbuilding Annex in Volume II of the Report

discusses in detail and lists certain of the aforelisted recommendations as they apply to seven categories of shipbuilding, namely:

- Special Characteristics of the Ship Acquisition and Special Problem Areas
- Development of Ship Operational Requirements and Their Translations into Ship Acquisition Specifications
- Principal Issues Relative to Acquisition and Test of Naval Combatants
- Special Organizational Considerations in Ship Acquisition
- Adequacy of the Shipbuilding and Ship Repair Capacity for Navy Ship Programs
- Summary of the Shipbuilding Claims Problem and Progress Toward Reduction of the Claims Backlog
- Summary of NMARC Recommendations Directly Related to Shipbuilding, Ship Conversion and Ship Repair

With specific reference to cost estimating, the NMARC Report states:

" Previous studies of cost estimating and the use of cost estimates during the years 1969 to 1970 identified problem areas in the Navy's estimating capability, in the adequacy of the Navy's cost data banks, and in the Navy's use of cost estimates in the planning, budgeting, and acquisition process. Since that time, the Navy has improved in these areas, but more improvement is required if the Navy's cost estimating is to be of superior quality and credibility with DOD and the Congress."

"Existing estimating staffs are professionally competent and produce better estimates than they are sometimes given credit for. However, staffing continues to be a problem in all three Naval Systems Commands (SYSCOMs)."

"Functional responsibilities have been added to the established cost-estimating groups without added resources to carry out the functions. Functions such as economic forecasting, economic analysis, and support for life cycle cost and design-to-cost, all of them important, have been added during periods when staff increases have been virtually unobtainable and, in the instance of NAVSEA, when staffs have been actually reduced. This work dilutes the effort required to perform the basic acquisition cost estimating responsibility and reinforces the need for additional staffing."

A review of the various recommendations indicates that 26 have some direct or indirect application to the estimating process. These recommendations are:

Recommendation OVRVW-7: Positive measures should be taken by OPNAV to ensure that changes to program scope and requirements are accompanied by corresponding adjustments to cost estimate baselines and budgets.

Recommendation PROC-8: The Navy should closely examine the problems associated with downward pressures on program estimates with a view to formulating policies aimed at elimination of such practices, which are the genesis of cost growth and claims and ultimately of Congressional antipathy,

Recommendation PROC-12: The Navy should improve the reliability of estimated program costs it presents to Congress. The responsibility for the preparation of baseline cost estimates should be assigned to the SYSCOMs. Detailed baseline estimates with associated rationale should be developed for each major program. The baseline estimate should be made a matter of record and should not be changed except when justified by modifications to scope and then only when completely substantiated in writing.

Recommendation PROC-36: The policy of allowing only one estimating authority for ship acquisition programs (NAVSEA 052) should be continued. Baseline estimates should not be changed without sufficient cause. Any change should be documented.

Recommendation PROC-37: If a program is not funded at a level that supports the NAVSEA-approved estimate, the scope of the program should be reduced if that is feasible, or the program should be stopped.

Recommendation PROC-40: NAVSEA should continue the present emphasis on increasing the scope of the design effort going into the contract plans and specifications to provide greater assurance that a valid estimate can be made, a fully responsive design developed, and the resultant ship built at reasonable cost.

Recommendation PROC-46: NAVSEA and the Shipbuilders Council should undertake a study to develop indices that are adequate to reflect shipbuilding cost escalation.

Recommendation PROC -47: NAVSEA and the shipbuilders should schedule ships more realistically and/or NAVSEA should provide that the escalation would apply to some reasonable period of delay (possibly 1 year) in the completion of each ship in a series.

Recommendation COST-1: Emphasize the importance of the cost estimating function throughout the command chain.

Recommendation COST-2: Provide adequate staffing, training, and career patterns in the cost estimating and cost analysis function.

Recommendation COST-4: Provide the three SYSCOM estimating groups (NAVSEA and NAVAIR now exist; NAVELEX is proposed) with the independence and top management support necessary for the preparation of quality estimates by having these groups report at an appropriate level in the SYSCOM that will insure this support and independence.

Recommendation COST-5: Instill in all areas of command the importance of cooperating with and providing, in a disciplined and timely fashion, to the estimating function the most complete information available concerning the technical definition, risk assessment, quantity requirements and schedule parameters on which to base estimates.

Recommendation COST-6: Enforce OPNAV Instruction 4700.12C. Provide for greater discipline in the planning phase and during the complete budget cycle to insure that late changes to programs are minimized and that the number of programs for which budget quality estimates are required are held to the prime candidates to diminish the use of less then Class "C" estimates in budgets.

Recommendation COST-7: Make it a firm policy in each SYSCOM to provide the cost estimators and cost analysts with access to the detailed cost data supplied by contractors in support of proposals and with the contract costs reported in accordance with the criteria established by DOD Instruction 7000.2 or other contract cost reporting requirements.

Recommendation COST-8: Include a contingency in the estimate whenever a less-than-budget-quality cost estimate is to be included in the budget.

Recommendation COST-9: Directed cost estimates that modify those prepared by the responsible cost estimating functions should be identified as such. This identification must include the identify of the person or authority responsible for the directed cost estimate.

Recommendation COST-10: Reduce layering of cost estimating and layering of the review and analysis of cost estimates.

Recommendation COST-15: Set realistic schedules and recognize schedule risk in prime contracts. Plan for schedule risk in GFE delivery and/or, if this is not feasible, consider CFE procurement.

Recommendation COST-18: Continue to apply design-to-cost principles, especially in preliminary design. Understand where the cost really is: emphasize the quality of the estimate which sets the cost goal.

Recommendation COST-32: Integrity of any data bank resulting from contractor cost data reporting should be maintained with respect to accuracy, completeness (of data), and limiting access to those with a legitimate need to use the data to develop cost estimates. This should be done to prevent compromise, misuse, or misapplication of the data.

Recommendation COST-59: The Navy should obtain agreement with DOD and OMB for the elimination of the use of other than the most realistic projections of economic escalation in estimating and budgeting for major weapon systems.

Recommendation COST-60: The Navy should improve its in-house capability to forecast the effect of economic escalation. At the present time, NAVSEA (SHIPS) has the most proven capability. Except in NAVSEA and NAVAIR, this ability does not exist to any marked degree. Overall policy guidance must be developed, and the capability of each SYSCOM and PM-1 must be strengthened. Overall DOD direction should be provided by ASD (Comptroller) and OMB's approval should be obtained.

Recommendation COST-62: The Navy should improve its major weapon system scheduling. The projection of realistic schedules, taking into account the best available information on lead times for material acquisition and taking into account the time required to accomplish the scope of work, is necessary if the provisions for economic escalation are to bear a reasonable relationship to actual experience.

Recommendation COST-77: Undertake a full study to determine the extent of reserve requirements and to make specific recommendations as to the manner in which they should be developed, controlled, and applied. The study should be conducted so as to provide for OSD, OMB, and Congressional input/participation to insure appropriate perspective and to facilitate implementation of study results.

Recommendation COST-79: Encourage development of budgets that both recognize risks (Cost Panel Section 4) and request funding more toward contract ceiling (including reserves) in order to fund probable system costs.

Recommendation COST-80: Utilize system cost estimates developed in the SYSCOM that include a certain percentage (e.g., 5 to 15 percent) of the base estimate as a management reserve.

18. REPORT OF ASSISTANT SECRETARY OF THE NAVY TO SECRETARY OF THE NAVY

Subject: Financial Management Planning Group Inflation Study

Date: April 11, 1975

The study was conducted to determine the extent of projected inflation on Navy programs by appropriation (SCN, APN, WPN and MILCON) and to examine techniques used to project it.

The most recent Wharton forecast of the GNP deflator and the forecast of the CNP deflator published in the President's budget were used as the baseline indices and were compared to that forecasted in each appropriation. It was found that for existing programs up to 1980 there will be a further erosion of a total of $20 billion over and above what was included in the estimates if the economy behaves as forecasted by the most recent baseline indices.

The study report provides narratives and graphs relating to forecasts by different methods for each of the major appropriations.

All the forecasting methodologies reviewed in this study were considered reasonably successful in projecting normal inflation; however, none of the methods (including the Wharton model) forecasted the unprecedented inflation of 1974.

The study considered that the OSD indices, particularly the procurement index (which is used in some of the appropriations) was consistently projected too low. Of specific interest is the observation that only the NAVSEA projection for inflation in the SCN appropriation was higher than the two baseline projections which were considered conservative (low). All other appropriations which projected inflation were lower than that projected by the baseline forecasts.

Conclusions

- Department of Navy should develop a set of escalation price indices to relate to specific weapon systems, goods, and services purchased by DON. It should rely on econometric models, BLS data, and recent DON cost experience.

- Past price changes in appropriations not monitored before should be measured for future decision-making. An index based on a separate "market basket" for each appropriation should be constructed.

- A system should be established for predicting future prices that is tied to the indices used to measure historical price changes.

- A method for accommodating inflation in annual accounts should be pursued. It would operate as follows:

- The budget would be tied to prices as of a given date.
- The price level would prevail in the budget submitted to Congress.
- The budget would be indexed to a new price level at an appropriate future date.
- The President would provide Congress with an estimate of inflation during the fiscal year in which the budget would be executed.

. The constant dollar baseline should be preserved for inflation estimates and comparison of actual experience. Related documents should have a separate line item for inflation estimates, which should be justified by exhibits showing methodology.

19. ACQUISITION ADVISORY GROUP REPORT

Subject: Report of the Acquisition Advisory Group to Deputy Secretary of Defense

Date: September 30, 1975

The Acquisition Advisory Group (AAG) was established on 28 April 1975 by the Deputy Secretary of Defense. Its purpose was to examine and assess the recommendations contained in the reports of the Army Material Acquisition Review Committee (AMARC) dated 1 April 1975, the Navy Marine Corps Acquisiton Review Committee (NMARC) dated January 1975, and related recommendations submitted by the Secretary of the Air Force as they relate to "the organizational make-up, directives, instructions or other guidelines of the Secretary of Defense pertaining to major weapon systems acquisition within the Office of the Secretary of Defense."

On the basis of an assessment of the aforementioned major weapon systems acquisition studies, and discussions with a broad spectrum of responsible individuals in the Military Departments, Office of Secretary of Defense, General Accounting Office, Congressional staffs and defense industry, a number of recommendations were formulated in the following topic areas:

Secretary of Defense Control of Defense System Acquisition Review Committee (DSARC)

Recommendations:

- That the DSARC function as an executive advisory body and confine their attention to decision point assessments, i.e., I, II, or III as defined in DOD Directive 5000.1.

- That the distinction between Program Management Reviews and DSARC decision point assessments be precisely established.

- That the number of major acquisiton programs subject to formal DSARC process at OSD level be reduced to approximately 40 programs; delegate responsibility for remainder to Service Secretaries.

- That the DepSec Def consult with the Service Secretary prior to action on DSARC recommendations.

- That responsibility for all Program Management Reviews remain primarily with the Service Secretaries.

- That the DepSec Def strengthen his immediate control by designating himself as Chairman ex-officio of the DSARC.

- That the DepSec Def establish the position of Special Assistant for Acquisition reporting directly to him.

- That the OSD staff engaged in major systems acquisition be reduced commensurate with the recommended reduction in level and detail of DSARC activity.

Mission Needs and Requirements

Recommendations:

- That a continuing series of Mission Area Analyses be established in DOD and initiated and conducted by the Services under the functional guidance of the Assistant Secretary of Defense (Program Analysis and Evaluation) (ASD(PA&E)).

- That the Services initiate and conduct Mission Concept Studies to determine ways and means of meeting mission needs under the functional guidance of Director of Defense Research and Engineering (DDR&E).

- That the Mission Concept Studies explore and evaluate competing system concepts and be used as the basis for development of the initial Development Concept Plan (DCP).

- That the establishment of precise performance characteristics for a weapon system be prohibited until such time as the candidate system is approved for full-scale development.

- That the Director of WSEG be authorized to conduct independently such additional studies (both Mission Area Analyses and Mission Concept Studies) as he deems necessary to assist the DepSec Def in decisions on acquisition needs.

Cost Analysis, Control and Reporting

Recommendations:

- That the SecDef establish policy and criteria to incorporate procedures for treating program and cost uncertainty in all cost estimates, forecasts, reports and announcements on major defense systems.

- That the Assistant Secretary of Defense, Comptroller (ASD(C)) in concert with the Military Departments undertake a review of the Selected Acquisition Reporting System (SAR) to streamline the system and to provide for the inclusion of ranges in the estimates of performance and costs.

- That action be taken to insure effective coordination and integration of OSD management control systems that interact with the DSARC process and related Service processes.

- That the ASD(C) be assigned the responsibilities outlined in DOD 5000.4 (Cost Analysis Improvement Group).

Foreign Military Sales

Recommendations:

- That the DepSec Def initiate a review to assess the impact of the growing FMS program on DOD's major defense acquisitions and to formulate appropriate management policies and procedures to cope with it.

- That the DepSec Def require the OSD, the Services, and defense agencies to include consideration of FMS impact in defense systems acquisition management and decision point assessment reviews.

Acquisition Management and Program Managers

Recommendations:

- That the SecDef promulgate a Directive on acquisiton management to:

  - Clearly set forth the authority, responsibility and accountability of program managers.

  - Require establishment of clearly defined command lines for acquisition from SecDef to the program manager.

  - Emphasize accountability of reviewing executives in command line.

  - Authorize the delegation of authority to program managers to make trade-off decisions involving program schedule, cost and performance requirements within specified ranges.

- That the SecDef:

  - Hold Service Secretaries accountable for the appointment of qualified individuals in the acquisition management line above a designated level.

- Require early action in implementing DODD 5000.23 (Systems Acquisition Management Careers).

With specific reference to Cost Analysis, Control and Reporting, the AAG finds that the credibility of the DOD in the financial management of major defense acquisition programs is held suspect both inside and outside the Pentagon. Financial management utilizes cost estimating, cost management, and cost reporting systems to support the planning, programming and budget system. The AAG believes a comprehensive and specific effort should be initiated both in OSD and in the Military Departments to bring about significant improvements both in the financial management of major defense systems and in presentation and justification of realistic cost projections for these systems.

20. REPORT TO THE CONGRESS BY THE COMPTROLLER GENERAL OF THE UNITED STATES

Subject: Financial Status of Major Acquisitions as of June 30, 1976

Date: January 18, 1977

The report was developed pursuant to the Budget and Accounting Act, 1921 and the Accounting and Auditing Act of 1950. The report concerns the financial status of major acquisitions of the U.S. Government including acquisitions financed solely with Federal Funds and those financed jointly with Federal, State and other funds.

Defense weapon systems acquisitions listed in the report cover only major programs, i.e., RDT&E programs in excess of $50 million or an estimated production cost in excess of $200 million. For civil agencies, the GAO used a uniform threshold of $25 million. The same $25 million base was used also for DOD computer acquisitions and military construction projects. The projects reported were past the planning stage and in development, test, production or construction phases. Completed projects were not included.

The report indicates that 753 civil and military acquisitions checked had an original expected cost of $276 billion at their early or development stages and are currently estimated to cost $452 billion or an increase of 64 percent. For 201 projects (148 civil and 53 military) analyzed by the involved agencies,

costs increased by $150.9 billion of which 47 percent is attributed to inflation (i.e., economics). The agencies attributed these increases to:

- Quantity -- changes including scope
- Engineering -- changes altering the established physical or functional characteristics of a system
- Support -- changes involving spare parts, ancillary equipment, warranty provisions, and Government-furnished property and/or equipment.
- Schedule -- changes in delivery schedule adjustments, completion date, or some intermediate milestone of development, production, or construction.
- Economic -- changes that are influenced by one or more factors in the economy, such as inflation.
- Estimating -- corrections or other changes occurring since the initial or other baseline estimates for program or project costs were made.
- Sundry -- changes other than the above categories, such as environmental costs and relocation assistance for water and highway projects.

The various agencies self-analysis of the overrun causes are listed below:

	148 Civil Acquisitions (1)		53 Defense Acquisitions (2)		Total Agencies	
Type of Change	Total Changes (Billion)	Percent	Total Changes (Billion)	Percent	Total Changes	Percent
Quantity	$12.9	14.3	$ 6.5	10.7	$19.4	12.8
Engineering	24.9	27.5	4.4	7.2	29.3	19.4
Support	.3	.3	1.4	2.3	1.7	1.1
Schedule	1.1	1.2	11.0	18.2	12.1	8.0
Economic	42.7	47.4	28.2	46.5	70.9	47.0
Estimating	3.7	4.1	5.3	8.8	9.0	6.0
Sundry	4.7	5.2	3.8	6.3	8.5	5.7
Total	$90.3	100.0	$60.6	100.0	$150.9	100.0

(1) 148 acquisitions having 100 percent or more cost growth
(2) Cost data extracted from 53 Selected Acquisition Reports on weapon systems

While economic factors, chiefly inflation, caused almost one-half of the increases in both civil and defense agency acquisitions, the civil agencies also give considerable weight to engineering and quantity causes in that order, with estimating representing only 4.1 percent of the increases. After inflation, the defense agencies also give considerable weight to schedules and quantity in that order, with estimating representing 8.8 percent of the cost increases.

Attachment B.2 hereto attached is the "Financial Status of Major Acquisitions, Summary by Agency at June 30, 1976". An analysis of those agencies with acquisition programs of $1 billion or greater indicates the following anticipated increases over the baseline estimates:

	Percent
Appalachian Regional Commission	580
Department of Air Force	49
Department of Army	36
Department of Navy	43
Department of Army, Corps of Engineers	11
Bureau of Reclamation	72
National Park Service	27
Federal Highway Administration	160
Federal Railroad Administration	0
Urban Mass Transportation Administration	9
Energy Research and Development Administration	46
Environmental Protection Agency	37
National Aeronautics and Space Administration	24
Tennessee Valley Authority	36
Washington Metropolitatn Area Transit Authority	121

The Report states:

> "Unanticipated development difficulties, inflation, faulty planning, poor management and poor estimating will increase the costs of major acquisitions. Cost growth cannot always be prevented or anticipated, particularly when a project is in development and production over long periods".

Conclusions

Cost growth for civil programs are greater than for Department of Defense. This is somewhat surprising since many defense projects are inherently more complex than civil projects, require longer construction periods and represent programs with a higher level of technology. The GAO recognizes certain problems when it states "cost growth cannot always be anticipated, particularly when a project is in development and production over long periods".

Civil and defense programs encountered almost half of their cost growths due to inflation. Since many of the programs were budgeted prior to 1973 and 1974, this would be expected. The portion of overruns due to estimating is stated to be 4.1 and 8.8 percent, respectively, for civil and defense acquisitions. The report indicates the many factors that result in overruns. It is obvious that the causes must be minimized or adequate provision made in estimates to provide for the many contingencies to be encountered.

ATTACHMENT B.2

FINANCIAL STATUS OF MAJOR ACQUISITIONS
SUMMARY BY AGENCY
AT JUNE 30, 1976
(DOLLARS IN MILLIONS)

AGENCY	REFERENCE PAGE OF APP. II	NUMBER OF PROJECTS	ORIGINAL ESTIMATE	BASELINE ESTIMATE	CURRENT ESTIMATE	INCREASE OVER BASELINE ESTIMATE
APPALACHIAN REGIONAL COMMISSION	5	1	1,150.0	1,150.0	7,858.0	6,708.0
ARCHITECT OF THE CAPITOL	5	2	122.9	122.9	208.1	85.2
DEPARTMENT OF COMMERCE:						
MARITIME ADMINISTRATION	5	1	156.7	156.7	156.7	
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION	5	5	303.5	305.1	334.0	28.9
DEPARTMENT OF DEFENSE:						
DEPARTMENT OF THE AIR FORCE	6	32	44,780.8	53,754.7	80,099.9	26,345.2
DEPARTMENT OF THE ARMY	8	40	25,556.6	27,205.4	36,799.5	9,594.1
DEPARTMENT OF THE NAVY	11	75	78,625.6	89,316.4	127,355.3	38,038.9
DEPARTMENT OF HEALTH, EDUCATION AND WELFARE:						
ALCOHOL, DRUG ABUSE AND MENTAL HEALTH ADMINISTRATION	17	1	130.3	130.3	130.3	
NATIONAL INSTITUTES OF HEALTH	17	2	66.0	95.2	95.4	.2
DEPARTMENT OF JUSTICE:						
FEDERAL BUREAU OF INVESTIGATION	18	1	55.4	55.4	57.2	1.8
DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS	18	178	8,799.3	12,728.5	26,742.3	14,013.8
DEPARTMENT OF THE INTERIOR:						
BONNEVILLE POWER ADMINISTRATION	32	6	313.9	330.9	454.1	123.2
BUREAU OF RECLAMATION	32	51	7,257.1	7,612.2	13,133.3	5,521.1
NATIONAL PARK SERVICE	37	27	1,306.8	1,502.6	1,910.4	407.8
DEPARTMENT OF TRANSPORTATION:						
FEDERAL AVIATION ADMINISTRATION	39	6	587.9	621.1	677.3	56.2
FEDERAL HIGHWAY ADMINISTRATION	39	6	38,044.4	38,045.0	98,700.8	60,655.8
FEDERAL RAILROAD ADMINISTRATION	44	1	1,900.0	1,900.0	1,900.0	
U.S. COAST GUARD	45	7	700.3	700.3	931.5	231.2
URBAN MASS TRANSPORTATION ADMINISTRATION	45	46	6,633.5	6,635.0	7,211.5	576.5
DISTRICT OF COLUMBIA GOVERNMENT	52	12	668.0	668.0	709.7	41.7
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION	54	38	6,524.8	6,536.8	9,546.6	3,009.8
ENVIRONMENTAL PROTECTION AGENCY	58	155	7,105.0	7,105.0	9,771.3	2,666.3
GENERAL SERVICES ADMINISTRATION	71	15	606.1	761.4	820.4	59.0
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION	72	13	6,862.1	7,305.7	9,022.9	1,717.2
NATIONAL RAILROAD PASSENGER CORPORATION	73	5	377.1	377.1	559.5	182.4
NATIONAL SCIENCE FOUNDATION	73	1	76.0	76.0	78.1	2.1
TENNESSEE VALLEY AUTHORITY	73	18	8,032.0	8,032.0	10,930.0	2,898.0
VETERANS ADMINISTRATION	75	7	337.2	365.1	474.0	108.9
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY	75	1	2,494.6	2,494.6	5,512.3	3,017.7
TOTAL		753	249,573.9	276,089.4	452,180.4	176,091.0

APPENDIX C

MANAGEMENT OF THE SHIP ACQUISITION PROCESS

Appendix 3 of 5

In Support of the Final Report entitled, "A Study of Ship Acquisition Cost Estimating In The Naval Sea Systems Command".

Contract No. N00024-77-C-2013

INTERNATIONAL MARITIME ASSOCIATES, INC.
WASHINGTON, D. C.

OCTOBER 1977

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I INTRODUCTION

This Appendix, Management of the Ship Acquisition Process, is a detailed review and analysis not only of the SCN POM and budget sequences, but of the entire Planning, Programming, and Budgeting System as well as the Phased Ship Acquisition procedure.

The Appendix starts with a review of key DOD organizational elements involved in the shipbuilding process and proceeds through the complex funding system. The structured sequence of PPBS and its relationship with cost estimating involves a related series of events during and following authorization of funds -- the engineering and construction process itself. The seven major phases of the Acquisition Process are discussed briefly. These two systems in conjunction should provide stable programs, reasonable lead times for preliminary engineering and design, comprehensive and accurate data, and a general reduction in risk.

Also covered are other less structured procedures which bear on cost control and management information.

- Selected Acquisition Reports (SARs)
- Ship Cost Adjustment Reports (SCAs)
- Procurement Accounting and Reporting System (PARS)
- Contractor Cost Data Reports (CCDRs)

Chapter II of this Appendix is a general discussion of management systems utilized in ship acquisition. Chapters III and IV are a step-by-step description of the detail of the major systems -- PPBS and the Phased Acquisition Process.

II MANAGEMENT OF NAVAL SHIP ACQUISITION

DOD management systems are an attempt to minimize uncertainties which affect management decisions. When cost estimates are used in the planning process, they are critical to providing management the ability to create a balanced, capable force structure within the fiscal limitations allowed. Preparation of an estimate with that kind of accuracy, however, requires a stable program stream that allows time for preliminary development activity.

An interdependency exists, then, between the system and the estimate. Both must work in harmony for either to function correctly.

- First, to estimate accurately for future programs, planning must develop a relatively stable program -- not only for the short term, but up to five or six years out.
- Second, given a stable program, sufficient design and engineering activity must take place to allow a reasonable base for cost estimating.
- Third, estimators must use consistent and professional methods to provide accurate enough information for proper management decisions about program worth versus available resources.

The system, in its attempt to preclude uncertainty, has unusual obstacles in the case of shipbuilding. An expert on the construction of combatant ships, Dr. Timothy Shea, has said recently that the principal uncertainties in estimating ship cost arise from five factors:

> "(1) the long period of years required for planning, designing, and building a quantity of ships, (2) the complexity of modern warships, (3) uncertainties as to shipyard (and equipment manufacturers') capability and efficiency, (4) uncertainties in shipbuilder's overhead, and (5) under certain conditions, uncertainties in the cost of correcting deficiencies."

The following sections, then, describe the roles of various procurement-related organizations and the systems which guide their activities.

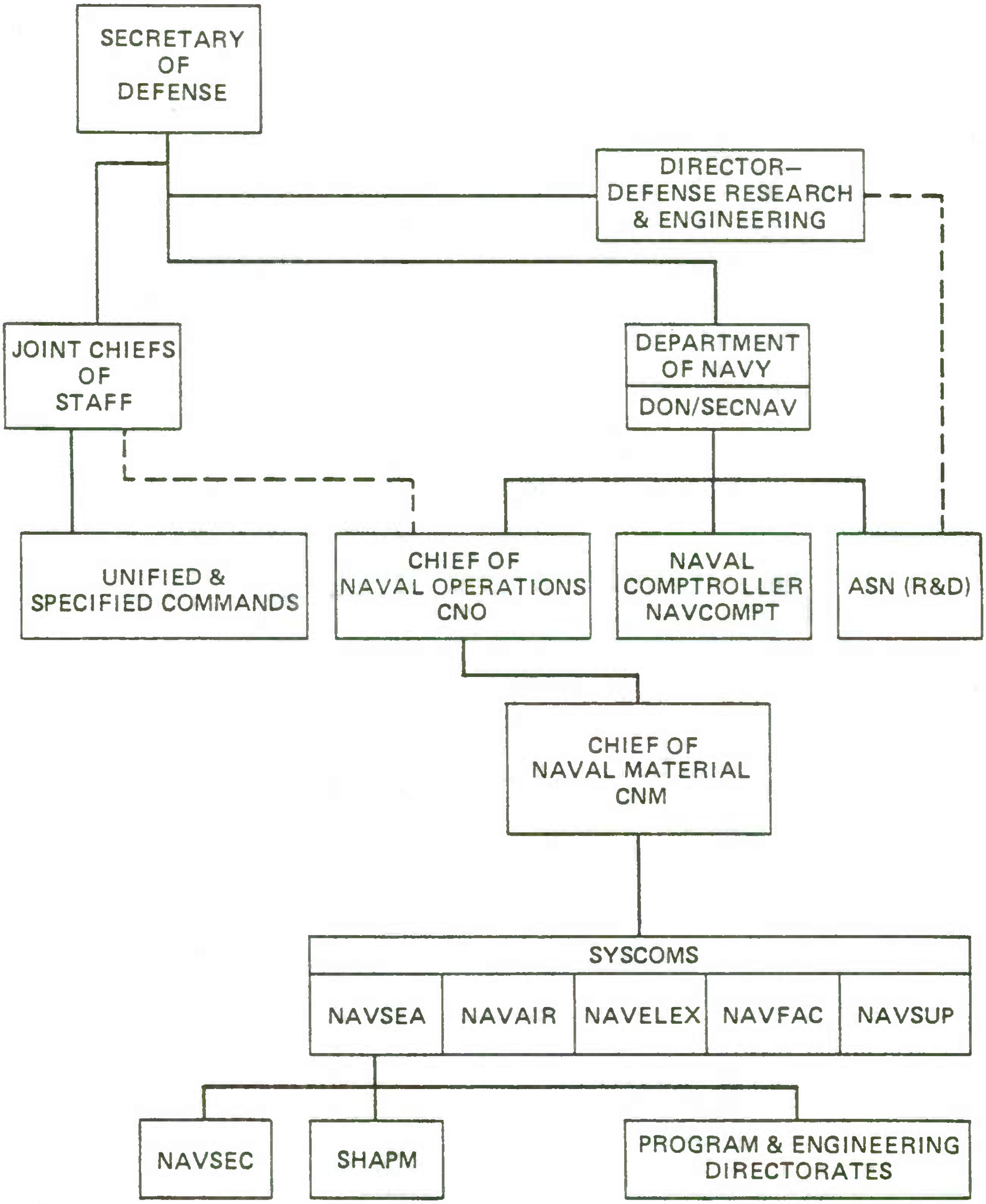
1. NAVAL SHIP ACQUISITION INVOLVES MANY ORGANIZATIONS WITHIN THE DEPARTMENT OF DEFENSE (DOD)

Figure C.1 identifies key organizations involved in the ship acquisition process. It traces the bilinear organization of DOD under the Secretary of Defense with the Joint Chiefs of Staff managing the operating forces on one side and the Service Heads managing logistical support on the other. Within the Navy itself, all acquisition functions -- from planning through construction -- are carried on by the Chief of Naval Operations, the Chief of Naval Material and the Systems Commands. Each organization plays a specific role in the process.

FIGURE C.1

DOD ORGANIZATION

KEY ORGANIZATIONAL ELEMENTS INVOLVED WITH SHIPBUILDING



(1) <u>The Role Of The Joint Chiefs Of Staff Is Operations Planning</u>

There is constant activity directed by this group toward identifying possible needs for new force structures by responding to intelligence and threat assessments in the light of national objectives, treaty obligations, current equipment inventories and apparent deficiencies.

Their planning is carried on in the context of the Five Year Defense Plan (FYDP) -- the primary management document within DOD. The FYDP contains fundamental information which is used by the Department of Defense to tie together the diverse activities required to fulfill its charter. It describes what has been accomplished in programs during the past 15 years, what is happening currently, what can be expected in the short term future and what can reasonably be expected beyond the short term future. The program descriptions cover force structure requirements, manpower levels and funding in terms of total obligational authority. It is in the context of this document that planning for near and long terms, management decision-making for currently developing systems, force deployment and everyday problem solving is carried out.

The planning process develops specific recommendations with regard to the Navy shipbuilding program.

- The Joint Intelligence Estimates for Planning and the Joint Long Range Estimative Intelligence Document identify new developments in foreign countries including ship design, technological breakthroughs, deployed or about-to-be deployed systems considered to be threats, and other data influencing plans for future sea-going forces.

- The Joint Long Range Strategic Study and the Joint Research and Development Objective Document provide the conceptual basis for current and future R&D activities. This direction assures that adequate and timely solutions are found to counter expected long-range threats to national security.

- The Joint Strategic Objectives Plan proposes specific modernization and new construction plans over the mid-range periods.

- The Joint Forces Memorandum details specific cost-constrained recommendations which bear on procurement and conversion programs.

- The Joint Strategic Capabilities Plan informs the Unified and Specified Commands of specific plans bearing on ship operations, maintenance and projected force capability over the short term period.

- Finally, the planning base which issues from this process provides a roadmap for service personnel to follow in meeting their individual planning and programming responsibilities.

This planning material is provided to the Secretary of Defense (SECDEF) and represents a point of view particularly oriented to plan-

ning options and associated risk. Little is covered which is fiscally constrained. As a result, little use is made of the studies outside of SECDEF -- almost never in the Systems Commands, for example.

(2) The Role Of The Chief Of Naval Operations Is Requirements Definition And Acquisition Management

Most shipbuilding activities -- from the statement of Operational Requirement to post construction testing and turnover of the fleet -- are carried on under the direction of the Chief of Naval Operations (CNO). Activities which are not the direct responsibility of the CNO relate to early Research and Development. The Operational Requirement (OR) is the basic requirements document for all Navy acquisition programs requiring developmental activities. It is a concise statement of an operational need issued for the purpose of initiating efforts to meet that need.

The primary responsibility for a shipbuilding program under the CNO rests first with the Headquarters organization (NAVMAT) and second -- and most importantly -- with the Naval Sea Systems Command (NAVSEA). A single individual in NAVSEA is appointed Ship Acquisition Project Manager (SHAPM) and it is he who manages the ship program from approval of the requirement or turnover to the Fleet. In certain cases for highly important projects, the project office will

operate from NAVMAT. Supporting the SHAPM are various program and technical directorates within NAVSEA which provide design, engineering, financial and legal expertise. It is also in the charter of NAVSEA to act as coordinator or prime contractor when other naval commands are required to assist -- as with air or electronic systems (NAVAIR and NAVELEX).

(3) <u>The Role Of The Office Of The Secretary Of Defense (OSD) Is Review, Approval And Defense Resource Planning And Administration</u>

Activities of this office relate to review and approval of selected mission solutions within the spectrum of options available and coordination of acquisition with the Planning, Programming and Budgeting System (PPBS) and FYDP processes. In development stages, the Defense Systems Acquisition Review Council (DSARC) is the review and advisory body representing the Secretary of Defense which reviews system alternatives and develops options leading to informed decisions regarding proposed systems. For major ship acquisitions, DSARC usually meets on three occasions:

- DSARC I -- prior to preliminary design
- DSARC II -- prior to contract design
- DSARC III -- prior to detailed design and construction, lead ship

NOTE: DSARC IIIA may meet after lead ship construction to provide approval for follow ships.

DSARC reviews are the DOD management decision point and, therefore, a favorable recommendation by DSARC is tantamount to Secretary of Defense approval. This approval is expressed in the form of a Decision Coordination Paper (DCP) which documents important issues and considerations relating to the decision along with the chosen course of action.

There are many organizations within the DOD/Navy structure that participate in the acquisition process. The activities of these organizations are controlled by systems and procedures which address each aspect of ship and weapon acquisition. The primary and controlling system, however, is the Planning, Programming and Budgeting System (PPBS).

2. A HIGHLY COMPLEX SYSTEM FOR FUNDING (PPBS) PROVIDES THE BASIC FRAMEWORK FOR THE DECISION PROCESS WITHIN THE DOD/NAVY

The cornerstone of DOD management over many years has been the Five Year Defense Plan. It is a history of past accomplishments, a record of current activities, and a forecast of future objectives.

PPBS is really an updating system for the Five Year Defense Plan and is directed toward funding the programs of DOD. It is used by DOD to organize its complex activities into an understandable procedure with orderly schedules, cost assumptions, and event documentation. It is a continuous

operation involving almost every defense component. In most general terms, it is a "proposal, review, approval/disapproval, restatement, send to higher authority" process. It serves to provide the necessary forums for weeding out weaker programs and promoting those worthy of eventual implementation.

(1) "Planning" Establishes Goals For The Five Year Planning And Programming Period

In the planning system of the Joint Chiefs of Staff, the total defense posture is viewed in historical perspective, translated into presently required mission capability and projected in future force structure requirements with acceptable allowances for risk. Their deliberations result in recommendations to the SECDEF regarding general posture matters. These recommendations are the base from which the SECDEF planning guidance memoranda are prepared. Using these memoranda as a general roadmap, the individual services prepare a statement of their particular roles within the overall defense mission. This statement is submitted annually in the format of the FYDP and describes a total program annually for current and future years. The Navy planning documents are the Navy Strategic Study and the Department of the Navy Five Year Defense Plan.

It is important to mention here that the Planning activities for a particular future program year precede it by some 31 months. Programming begins about 27 months in advance; Budget formulation 17 months and Budget appropriation and apportionment, about nine months. The long PPBS cycle requires, therefore, that in any one year, four different cycles be handled in one way or another as Figure C.2 shows. As the 1977 budget is being executed, the 1978

FIGURE C.2

PARALLEL ACTIVITIES IN PPBS OPERATION

FISCAL YEAR N	FISCAL YEAR N + 1	FISCAL YEAR N + 2	FISCAL YEAR N + 3
PLANNING PROGRAMMING BUDGETING	PLANNING PROGRAMMING	PLANNING	
EXECUTION	BUDGETING	PROGRAMMING	PLANNING
	EXECUTION	BUDGETING EXECUTION	PROGRAMMING BUDGETING EXECUTION

PARALLEL ACTIVITIES CARRIED ON IN SAME YEAR FOR DIFFERENT PROGRAM YEARS

budget is being formulated (budgeting) by the Department of Defense and individual services; the 1979 Program Objectives (programming) are being documented; and the 1980 program year planning is being performed.

Cost estimates must be prepared annually for ships in all phases of the PPBS cycle. To prepare reasonably accurate estimates of the costs of these ships (the earliest of which may not be placed under contract for two to three years) requires not only product definition appropriate for the class of estimate expected, but also an ability to predict the time frames in which the ships will ultimately be authorized, awarded and constructed.

(2) "Programming" Is The Translation Of Planning Goals Into Specific Programs Geared To Fiscal Realities

Programming activities for the five year plan extend over an 11 month period and begin with staff activities at the SYSCOM level as part of the CNO Program Analysis Process. In early stages, potential programs for future years are proposed by means of briefing presentations prepared by OPNAV mission and resource (platform and support) sponsors with staff assistance from appropriate SYSCOM personnel. The potential programs are reviewed during analysis

sessions held by the CNO and result in the issuance of CNO Program Analysis Memoranda (CPAM's). These memoranda explore alternatives and courses of action available for inclusion in the Navy's program. During CPAM analysis, sponsors for competing solutions appear at hearings to discuss the issues involved. Studies using the Resource Allocation Display cost model (a subset of the FYDP) are carried on concurrently with the CPAM process and assist in achieving the best mix of programs within anticipated funding levels. At the end of the CPAM process a Summary CPAM is drafted and approved by the CNO. He supplements the approved program draft with his first fiscally-constrained guidance, the CNO Planning and Fiscal Guidance Memorandum (CPFG).

The final stage of program development begins with a series of "exercises" to test out and firm up programs. Any adjustments necessary to weed out problems are made during these sessions where the sponsors review and define their programs. At the conclusion of the Sponsor Program Review, the CNO Executive Board (CEB) resolves major issues and finalizes the Summary CPAM.

The Program Objective Memorandum (POM) is the primary Navy program document and is submitted to the Office of the

Secretary of Defense by the Secretary of the Navy (SECNAV). The CNO provides SECNAV with the Summary CPAM together with the overall program rationale in his final guidance memorandum, the CPFG (II). SECNAV, after combining the Navy program with that of the Marine Corps, prepares and submits the final Navy POM to the SECDEF.

The POM's from each Service are part of a DOD review process -- Program Decision Analysis -- the purpose of which is to balance the service submitted programs and those of other DOD components to total available defense resources and settle, where appropriate, issues that arise during the programming process. These issue meetings and hearings are contained in Program Decision Memoranda issued by the Secretary of Defense which, along with the POM, are the definitive program documents. The so-called POM cycle is one of the major update triggers for the FYDP -- in May for POM data and in October to reflect PDM's.

(3) "Budgeting" Is The Proposal Of DOD/Navy And The Executive Branch To The Congress For Funding Of Specific Programs

Budgeting, in the most general sense, can be categorized into the following three activities:

- Budget Formulation -- DOD components (as with all other government organizations) prepare a budget for the fiscal year prior to the program year (or, in other words, the current year plus one). Budget formulation, as a procedure, refers to activities carried on to derive budget estimates from the approved program base and the combining of these estimates into a viable proposal to the Congress. The controlling organization within the Navy for budget formulation is NAVCOMPT -- the comptrollership function in SECNAV. Budget guidance is issued by the Comptroller to all lower echelon Navy organizations which organize and submit the latest and best estimates of what the approved program will cost during the budget year. After review and approval cycles by Command executives, individual budgets are assembled by the Office of the Comptroller into the NAVCOMPT Budget Submission.

  DOD components send their budgets to OSD for a joint OSD/OMB review. Major budget issues are presented, debated and brought to decision. The decisions are documented as Program Budget Decisions. The approved Defense budget is sent to the President for review and approval; then, printed and sent to Congress.

- Congressional Review and Appropriation -- Review of the budget by Congress is carried on chiefly by three committees in each chamber -- Armed Services Committees, Appropriations Committees and Budget Committees of the House and Senate, respectively.

Further coordinating activities are carried on by the Congressional Budget Office.

The function of the Armed Services Committees and their sub-committees is to understand the rationale behind programs presented; approve or disapprove proposals; in cases of disapproval, suggest alternative actions; and, finally, set an upper funding limit for appropriation guidance. In support of Congressional review, senior DOD officials deliver posture statements which summarize past accomplishments, mention unsolved problems and state goals for the current and upcoming years. Beyond this, other Defense officials are called by the Committees as required to discuss specific issues in terms of programs and funding. Once hearings are concluded, reports are prepared and each chamber passes an authorization bill which specifies approved programs and limits on total obligational authority. Any differences between Senate and House bills are resolved by a committee of conference and an amended Authorization Act is passed.

The Appropriation Committees of both Houses meet to hear posture statements from senior financial officials such as Secretary of Treasury, Director of OMB, etc. Once the fiscal groundwork is laid, witnesses from individual Government departments and military services are called to justify their programs. Upon completion of the hearings, the subcommittees prepare bills for full committee amendment and/or adoption.

The Budget Committees (supported by the Congressional Budget Office) set national fiscal policy and priorities for federal programs which guide the deliberations of other committees. Budget Committee recommendations are the basis for the concurrent resolutions adopted by the Congress which provide the framework for the work of all committees.

Appropriation bills are passed by each Chamber, a committee of conference resolves differences and the Appropriation Bill is submitted for enactment by the Congress. The President's signature completes the enactment process.

- Apportionment and Allocation -- During the formulation and appropriation process, budget items are proposed which are different than those finally approved. In the apportionment process, determination is made by OMB as to the amount of funds which can reasonably be expected in the appropriation process and how much can be obligated during specified periods throughout the budget year and over the several years of multiple year appropriations under full-funding of projects. This prevents overspending of established funding authority and provides for orderly use of appropriated funds between Government departments. Apportionment parallels the appropriation process so that when the Appropriation Act is passed, a minimum of differences remain to be resolved.

The enactment of the Authorization Act, Appropriation Act and the granting of Obligational Authority subsequent to Apportionment all occur during the last quarter prior to the fiscal year being planned.

Apportionment defines funding authority to the level of a DOD component such as DON. Allocation and suballocation are terms used to describe the passage of funding authority below 'component level' to CNO, CNM and below that to fleet and SYSCOM levels in preparation of operation budgets.

(4) <u>Good Cost Estimates Are Critical To The Efficient Operation Of PPBS</u>

The importance of reliable cost estimates in the PPBS cannot be over-emphasized. This is particularly so as a program approaches the "Budget" phase. The credibility of the Navy as to its ability to estimate the cost of its programs is questioned when predicted costs are continually found to be too low.

Since Congress has primary control over the resources of the nation, estimates prepared by the Navy and submitted as part of the annual program are given careful scrutiny. PPBS was designed to give Navy decision-makers every opportunity to submit estimates which the Congress could consider as reliable.

PPBS controls the DOD/Navy organizations and processes by assuring that the following takes place:

- Planning to assure prudent risk-taking in developed force structures.
- Planning to optimize use of available resources.
- Program planning to present most feasible and timely development of systems.

- Programming of ships and weapons to optimize delivery and cost;

- Budget formulation which provides reasonably accurate funding estimates to carry out implementation of programs;

- Budget approval and appropriation procedures which guarantee full discussion of goals, implementation strategy and cost;

- Apportionment procedures to promote efficient systems development within legal, budgeted constraints.

3. THE PHASED ACQUISITION PROCESS INVOLVES ALL STEPS FROM IDENTIFICATION OF SHIP AND WEAPON REQUIREMENTS THROUGH DELIVERY OF THE COMPLETED SHIP

There has been an evolution in the methods used to procure combatant ships over the years.

Prior to 1966, ships were "designed to requirements" by the then Bureau of Ships. Design and engineering was carried on by the Navy with contracts being awarded generally after competitive bidding.

Around 1966, the idea that cost aberrations could be controlled by having the contractor build to his own design and engineering caught on. This was known as Total Package Procurement and was utilized in two ship programs between 1966 and 1972. The DD 963 class and the LHA 1 class were acquired using this method.

In 1972, the Department of Defense and the Navy changed to the current phased process of acquisition. The process is an amalgam of systems and procedures for producing one of the most complex engineered systems ever conceived -- a naval combatant ship. The phases and a brief identification of specific procedures within each phase follow.

(1) The First Phase Of Acquisition Is The Origination Of The Ship Requirement

This is begun in the planning process carried on by the Chief of Naval Operations, his deputies and sponsors. They arrive at specific proposals regarding ship types which will meet the envisioned threat which will replace obsolete ships and build up the fleet to planned levels.

(2) The Ship Requirement Is Then Validated By Issuing The Operational Requirement Document

The Office of the CNO (Force or Mission Sponsor) issues the Operational Requirement (OR) which sets forth the operational need and concept together with capabilities required including cost objectives. The CNO subsequently convenes the Ship Acquisition and Improvement Panel (SAIP) which, after a review of the requirement, appoints a Program Coordinating Committee to assist in preparing the Top Level Requirement (TLR) and Top Level

Specification (TLS). A Ship Acquisition Project Manager (SHAPM) is appointed by the CNO or his delegate.

(3) Early Design And Acquisition Planning Take Place In The Concept Phase

Based on information in the OR, the SHAPM prepares a Development Proposal (DP) for submission to OPNAV which proposes a specific approach to system development. This proposal eventually will be modified and updated to become a draft Decision Coordinating Paper (DCP). Having finished the DP, the SHAPM begins several activities intended to add substance to the system concept. These relate to preparation of outlines and preliminary reports for the Ship Acquisition Plan, Test and Evaluation Plan, Combat Systems Management Plan, Advance Procurement Plan, etc. The SHAPM also takes steps to activate the Ship Project Directive System which enables quasi-contractual arrangements to be made with other systems commands and technical organizations for ship design and for design, procurement or construction of Government Furnished Material (GFM).

Paralleling the SHAPM directed activities is the work of the Program Coordinating Committee which develops the TLR and the

TLS to reach a desired level of conceptual definition called a Conceptual Baseline.

At this point the DCP draft is updated to include information developed by the Program Coordinating Committee and the SHAPM, leading to the DNSARC and DSARC 1 proceedings. Assuming favorable response to system status, approval is granted to proceed with the Preliminary Design Phase.

(4) <u>The Functional Requirements Are Determined During The Preliminary Design Phase</u>

During this period, activities begun during the conceptual stage are continued from outline form to function design level. An example is the completion of the Combat Systems Management Plan which allows creation of the Combat System Design Requirement and the Combat System Operational Requirement. These activities are begun after CNO freezes the military payload of the ship.

Two new activities which relate to eventual post-construction use of the ship are begun. The Tactical Operational Requirement is drafted along with the Integrated Logistics Support Plan.

The additional information and specifications worked up during this phase are reflected in an updated TLR/TLS which reaches, at this point, the level of Functional Baseline. As with the conclusion of other phases, the DCP is rewritten in draft form reflecting new levels of development and the DSARC clears the way for contract design, full-scale development.

(5) All Remaining Activities Leading Up To Contract Award Are Completed During The Contract Design Phase

Activities in this phase are oriented toward creation of a specification package on which contractors are capable of bidding and which will provide a base from which to negotiate a contract with a selected builder.

A new activity begun in this phase is the preparation of the Program Integration Plan which seeks to tie weapons systems together with the required navagational, fire control and monitoring systems.

Increasing sophistication of ship specifications and confidence in program plans leads to the creation of the Contract Data Requirements List, Bid Specifications from the Allocated Baseline, Qualified Bidders lists and finally, the Request for Proposal.

The technical level of plans and specifications should allow, in this phase, cost estimates of C quality, scheduling estimates of fairly high reliability and evidence in final program reports that development is proceeding satisfactorily. Documents supporting this level of confidence are a final Ship Acquisition Plan; Combat System Design and Operational Requirements, Test and Evaluation Plan and the Ship Logistics Management Plan. Also, during this phase, specific projects for Government Furnished Equipment are funded and design/construction started.

The DCP/DSARC III process signals the end of the Contract Design Phase.

(6) <u>Detailed Design And Construction Of The Lead Ship Of A Class Follow Award Of The Contract</u>

This phase begins with the issuance of RFP's to qualified bidders; continues with submission of proposals and selection of contractor; further, to development of working drawings by the contractor and construction of the lead ship. During construction, the SHAPM activities are oriented toward overall administration of the contract, including review and approval of changes. GFM is delivered to the contractor and integrated into the ship on a scheduled basis.

The activities during construction can be summarized in general terms as follows:

- preparation of engineering specifications for procurement of Contractor Furnished Equipment
- laying down of ship's lines -- detailed engineering drawings
- purchase and receipt of materials, equipment and machinery
- pre-keel period -- fabrication of hull sections
- keel laying
- construction of hull up to and including deck houses, with simultaneous installation of major machinery, equipment and ship systems
- launching and removal to outfitting area
- post launch activities -- completion of contractor assigned work
- dock trials including 'fast cruise' simulations
- builder's sea trials
- INSURV trials
- correction of deficiencies
- delivery by contractor to owner (NAVY)
- commissioning and turnover of ship to fleet
- completion of fitting-out

- ready-for-sea period
- shakedown cruise
- post-shakedown period for correction of deficiencies

(7) In The Final Acquisition Phase, Production Of Follow Ships Is Carried Out

Not all programs go through lead ship construction prior to production of other ships in the same program. Often based on urgency of use, stability of specifications, etc., the production phase will preempt lead ship construction. However, if started somewhat ahead of the others, the lead ship in a program provides the opportunity to test and evaluate system and platform design and also construction methods, with an eye toward correcting any deficiencies or inefficiencies in future construction.

Important considerations in the production phase (which can extend for many years) relate to the number of ships built per program year, maintaining construction schedules in spite of possible disruptions -- material shortages, strikes, personnel turnover, economic instability, engineering changes brought on by new technology, etc. It is, therefore, in this period where cost growth may become most apparent. In general, construction and test activities follow the

pattern set in lead ship construction. Chapter IV includes a chart and description identifying major phases and events of the acquisition process.

4. MANY EFFORTS TO CREATE BETTER COST CONTROL AND MANAGEMENT INFORMATION ARE APPARENT

Outside of the two primary management and procurement systems, many other systems and procedures have been implemented over the years and provide the kind and quality of cost information that improves defense management. Several of these are the Selected Acquisition Report, Ship Cost Adjustment Report, the Procurement Accounting System and Contractor Cost Data Reports.

(1) Cost Histories Of Major Acquistions Are Followed On The Selected Acquisition Report

The interest that has developed over the last six or seven years with regard to cost growth in military hardware by Congress, Government agencies and the public in general influenced the Department of Defense to design a single report which would periodically provide cost and schedule information on major military systems. The report is called the Selected Acquisition Report (SAR).

It summarizes, quarterly, the status of programs designated by the DOD as major. The same criteria are used that apply to the DCP/DSARC process -- $75 million Research and Development, $300 million investment cost, national urgency or OSD special request. The summarization covers current estimates of technical, schedule, quantity, investment cost and cost variance data.

A second purpose of the SARs was to standardize definitions of key system development terms and concepts. Several reports are issued from the Navy which identify the current status of projects, but when read together, differences in terminology and definition have been a problem for management. An example of the problem is in the area of estimating System Acquisition Cost and comparing it to the current estimate of acquisition end cost. The problem of inflationary dollars in the current estimate, especially in times of economic instability, makes determining true cost growth difficult. The SAR

standardizes the definition so that the reader knows that acquisition cost and current estimates are in constant dollars computed by use of a deflator. Ostensibly then, the differences would indicate true cost growth without inflationary growth which is shown separately. Another task undertaken was to define escalation, inflation and other cost growth factors so that more precise measures of status could be developed. Although the objective of standardized definition has not totally been achieved, the SARs continue to reach in that direction.

The third purpose of the SARs which was intended to make them superior to other reports, was that it would follow a project from the time it became an official engineering program (usually after DSARC I) through the construction of follow ships in the production and turnover phase. This is accomplished in the SARs by showing prior year costs, current and budget year costs and finally, cost to complete. These three objectives characterize the SAR and are the basis for its broad use as an information document to organizations within and outside DOD.

Beyond that, the SAR should be compatible in content to the DCP and should be limited in length to around 10-12 pages. It is

issued 30 days subsequent to March 31, June 30, September 30 and December 31.

A specific format is required when preparing the SAR. It includes a cover sheet, summary page, and sections on technical aspects, schedule program costs, contractor costs, variance analysis and logistic support/additional procurement costs.

The Department of Defense is seeking to improve the usefulness of the SAR process and to correct certain problems remaining -- such as accuracy of deflators used and precision of computations on variance categories. In following progress on ship programs, it is a document which cannot be overlooked.

(2) New Ship Estimates Are Computed Semi-Annually And Reflected In The Ship Cost Adjustment Report

This report is the culmination of ship pricing analyses conducted for all ships and craft directly funded under the SCN Appropriation.

The first step in the SCA process is the development of the current best estimate of cost for each ship in the shipbuilding program. This takes into account the ship's characteristics promulgated by the

Chief of Naval Operations -- current electronics, weapons, other GFM prices and such miscellaneous factors as are necessary. NAVSEA is responsible for developing these estimates.

The second step consists of reviewing the status of the SCN Appropriation year figures and developing measures for balancing the program with available resources. The objectives of the SCA report are as follows:

- To provide an updated cost estimate of each ship program within the total shipbuilding program to all levels of management in the Department of the Navy.

- To provide data on which to balance the shipbuilding program with projected funding levels.

- To serve as a "baseline" for internal management of the shipbuilding program within the Naval Material Command.

- To provide the current financial status of the SCN Appropriations for the information of top management.

(3) <u>The Procurement Accounting and Reporting System (PARS) Is An Attempt At Achieving Uniform Procurement Reporting</u>

A major objective of PARS is to provide a uniform reporting capability for all procurement appropriations. This objective is met by the PARS output specifications which include a full range of required

financial and non-financial data in both detailed and summary type formats.

The financial and related non-financial information which is provided for management control of procurement activity includes the following:

- Financial data including initiations, commitments, obligations, accrued expenditures, and other funds data such as dollar reserves and amounts allocated or directed.

- Plans, including budget amounts, planned obligations and other financial data as well as non-financial data such as planned delivery dates and planned work completions.

- Estimates, both financial and non-financial, including those for such elements as costs to complete undefinitized change orders, and actual percent of work completed.

- Both funded and unfunded costs incurred on contracts.

The accounting and reporting procedure accommodates the procurement process by providing data on funds status and contract status for purposes of financial and management control.

(4) Contractor Cost Data Reports (CCDR) Were Initiated To Promote The Generation Of Returned Cost Data

The CCDR was developed to provide a consistent flow of uniform historical cost data for:

- Preparing independent cost estimates for major weapon systems acquisitions to be reviewed by the DSARC.
- Developing cost estimates in support of price analyses and contract negotiations.
- Tracking contractors' costs.

The system was implemented in 1974 by NAVMATINST 7000.23 and it superseded other methods such as Procurement Information Reporting (PIR) and Cost Information Reporting (CIR). CIR had been in being since 1966 and PIR since 1970.

The purpose is to collect contractor costs in terms of standard definitions against a uniform reporting structure integrated with other DOD control systems. Coverage is to commence at the point of Defense System Acquisition Review Council II approval for full scale development, and continue through completion of production.

CCDR has two categories of procedures.

- Category I -- applies to all new Department of Navy acquisition programs which are estimated to require RDT&E Total Obligational Authority in excess of $75 million dollars or cumulative production TOA in excess of 300 million dollars based on the Five Year Defense Program.

- Category II -- applies to smaller dollar value contracts in support of Category I programs, usually GFM systems/subsystems, or other acquisitions selected for control because of complexity, sole source supplier status, criticality, or future procurement plans. Sometimes the contract value is a consideration, in others, interest in standardized data submission may be the key.

The reports are prepared via the contractor's in-house accounting system and estimating procedures in accordance with the Government contract, and it continues as long as there is an active contract containing CCDR Requirements. The emphasis is on Work Breakdown Structure (WBS) elements in accordance with MIL Standard 881. It requires that a single Work Breakdown Structure be used for reporting all cost and cost related data for program management and cost estimating purposes.

5. THE ACQUISITION AND PLANNING PROCESSES HAVE A MAJOR INFLUENCE ON THE QUALITY OF COST ESTIMATING

The Navy planning and acquisition processes should provide an environment conducive to accurate estimating. It should provide, among other things, a stable program, reasonable lead times for preliminary engineering and design, proper data with which to work and it should reduce uncertainty and risk to a predictable level. Without this environment, it is exceedingly difficult to make accurate cost estimates.

The PPBS and the phased acquisition process, in conception and theory, are effective management tools. They provide a structure within which many people and organizations with varied charters are unified into a manageable whole. Certain problem areas have become apparent, however:

- At important decision points, such as the final program adjustment process or the submission of the final Navy budget, times alloted for organizations to adequately perform required activities are too short.

- Opportunities for changing a shipbuilding program within the PPBS number about 20 and many of these opportunities are utilized.

- These kinds of changes cause program instability which does not offer a solid base against which to estimate.

III PPBS CHART AND DETAILED DESCRIPTION OF ACTIVITIES

The primary funding system for ship and weapon acquisition is the Planning, Programming and Budgeting System. PPBS is utilized by DOD to organize its complex activities into understandable procedures through the use of orderly schedules, cost assumptions, and event documentation. PPBS involves the process of proposals, reviews, approval/disapproval of such, restatements, and the forwarding of proposals to higher authorities. The Planning, Programming and Budgeting cycle begins approximately 31 months prior to the funding year. Planning starts at 31 months, Programming at 27 months, Budget formulation at 17 months, and Budget Appropriation and Apportionment commences approximately nine months prior to the funding year.

Figure C.3 at the end of this chapter shows the Planning, Programming and Budgeting System in detail. The Figure outlines the procedures of Congress, the Joint Chiefs of Staff, Secretary of Defense, Department of the Navy/Naval Operations, and Claimants such as NAVMAT/Systems Commands/ Field Activities. The Figure also indicates the timing of the various activities.

Figure C.3 is a fold out chart and is keyed to paragraphs in this chapter which describe each activity. The blocks on Figure C.3 are

keyed to the narrative through a simple numbering system for clarity and ease of readability. The Figure and the narrative read in conjunction with each other will enable easier comprehension of the PPBS process.

31-A JIEP II -- Joint Intelligence Estimates for Planning

The JIEP is a document prepared annually which provides the intelligence base for planning documents issued by the Joint Chiefs. It is published in two volumes. Volume II, published in March covers the mid and short period (years 1-10) of the planning window starting with the current fiscal year. Volume I addresses the first two years (current and budget) of the 10 year window only. It provides intelligence information on world power relationships, regional problem areas and regional treaty organizations. Input to the document is reported by operational field components, headquarters service organizations and the Defense Intelligence Agency.

29-A JSOP I -- Joint Strategic Objectives Plan I

This document, on the basis of intelligence and information regarding potential threats to national security supplied in the JIEP and in light of the military ramifications of national security objectives, provides the strategy to be followed during the mid-range planning period. Volume I, Strategy and Force Planning Guidance, is addressed to the President, National Security Council, Secretary of Defense, Services and Unified and

Specified Commanders as the rationale for subsequent operational and logistics actions. This volume covers the following:

- Global and regional appraisals of major factors -- ideological, political, economic, military and psychological -- plus the rationale for planning options.
- Global and regional strategies.
- Guidance for employment and support of military forces.

27-A Claimant Staff Activities

SECDEF Program Reviews for the previous planning cycle are taking place and Program Decision Memoranda are about to be issued when staff work on the part of the field command, Systems Commands, NAVMAT, etc., is begun. The planning window from the last cycle is shifted ahead a year and programs slipped or dropped during the previous cycle are reviewed for possible entry during the current cycle along with new programs. Each defense component has its shopping list of projects for eventual inclusion in the total Navy program or POM and staff work on potential programs, options, courses of action to be pursued, etc., is carried on. In a sense, each Command and Division within them are doing their homework in preparation for the up-

coming official planning process.

The staff activities are supported by the Resource Allocation Display which is a display of the FYDP in program sequence rather than the appropriation sequence normally used in OSD. The first iteration of RAD is based on the October FYDP update which represents the POM or total Navy program of the previous cycle.

26-A JIEP I -- Joint Intelligence Estimates for Planning

The JIEP is kept up-to-date throughout the year, but in August, JIEP I is published and concentrates on providing definitive estimates for the short range period in support of planning and programming guidance.

25-A JLREID -- Joint Long Range Estimative Intelligence Document

The planning cycle extends out twenty years as to force structure projections in the FYDP. The JLREID addresses the planning years 11 through 20. It is in four parts, each of which covers a specific subject as follows:

- Major international developments
- Conflict possibilities
- Country and regional forecasts
- Technological developments of military significance

24-A JLRSS -- Joint Long Range Strategic Study

The intelligence estimates and threat data are used as background to the views of the Joint Chiefs on the U.S. military role in the 11 to 20 year planning period. The long range strategy is provided to the Secretary of Defense as background for studies, programming and policies developed in the shorter range periods. It is rewritten every four years and updated annually as necessary. The JLRSS covers the following:

- Major power alignments.
- Strategic appraisal of key factors -- ideological political, socio-eonomic, techno-scientific -- and guidance for eventual planning.
- Military roles required and necessary.
- Correlation of military roles and R&D goals for long range periods.

24-B DG -- Defense Guidance

The Defense Guidance is the beginning of the Programming phase of PPBS. Although the JCS planning phase still has some seven or eight months to run, the broad outlines of strategy and changes in direction have been worked out. Further, the FYDP has been updated for inclusion of previous cycle POM, PDM and

budget data. The SECDEF with this past year information, along with JSOP I, issues guidance for the newly beginning cycle with regard to manpower, recommended force structures, procurement, logistics, maintenance, etc. Additionally, areas the Secretary wishes emphasized are covered, i.e., improve anti-submarine warfare capability, improve ship modernization program, etc.

24-C FYDP/RAD I -- Resource Allocation Display I

Mentioned before as the first iteration of FYDP in a current cycle reflecting programs of the previous POM, PDM and NAVCOMPT Budget Submission, RAD I is a display of all current data by program for use in developing new requests and options.

23-A DNPPG -- Department of the Navy Planning and Programming Guidance

The Secretary of the Navy provides guidance to the CNO in a series of memoranda called DNPPG. It deals with items the SECNAV considers important and which should be taken into consideration during the current program cycle. Generally, specific mention is made of problem areas that, in the opinion of the Secretary, require attention by CNO, CNM, etc.

22-A JSOP II -- Joint Strategic Objectives Plan II

JSOP II covers planning in the mid-range area and translates the strategy outlined in JSOP I and Defense Guidance issued by SECDEF into force planning to support national military objectives. It presents the force levels in terms of risk categories, i.e., minimum risk and prudent risk. Minimum risk input is provided by the CINC's of the specified and unified commands, service components and the Joint Chiefs themselves. The force levels at minimum risk are naturally high and usually unattainable at current funding levels. The second level, or prudent risk, is developed and although more risk is inherent, the force levels are acceptable and usually higher than FYDP levels. The final section, in fact, shows the force recommendations at both JSOP II and FYDP levels. JSOP II shows the costs of recommended force levels but is not fiscally constrained in a programming sense. The cost estimates are useful to theSECDEF in preparing his fiscally constrained guidance, however.

It should be mentioned here that although each service prepares its own portion of JCS documents, all other services are part of the review process and when a document such as JSOP II is published, it is acceptable to each service for planning purposes.

22-B CPPG -- CNO Planning and Programming Guidance

Based on direction given by the SECDEF in the DG and the SECNAV in the DNPPG, the CNO starts program development within OPNAV by providing his guidance to appropriate sponsors. CNO views the Navy in terms of missions - Strategic, Sea Control, Projection ashore, Fleet Support, etc. - and each of these missions has a sponsor. The CPPG provides general guidance to each of the sponsors as to how the CNO views each mission and the accomplishment of its objectives. The sponsors take this advice into account in preparing their program development material. An example of his advice would be -- "emphasize mine countermeasure forces in the performance of the sea control mission".

21-A CPAM -- CPAM Briefing

This is a series of briefings in which the CNO Executive Board is brought up-to-date on the health of the Navy in terms of each mission. Strengths and weaknesses, obsolescence considerations, manpower projections -- are all typical areas of debate. The requirements of the mission

are listed and program development to meet those requirements are proposed. Usually two briefings per week are held to discuss mission effectiveness.

21-B FYDP/RAD II <u>Resource Allocation Display II</u>

During the CPAM phase of programming, the President's Budget representing the preceding cycle is submitted to Congress. It represents, therefore, the results and decisions of the SECDEF review of the prior year, OMB and Presidential review. It is the "approved program." The FYDP is updated at this time and the second iteration of RAD is produced for use by claimants and sponsors.

20-A JRDOD <u>Joint Research & Development Objectives Document</u>

The JRDOD builds on the strategic objectives in the long and shorter ranges and lists specific R&D objectives in the 2 to 20 year planning window. Its content is as follows:

1. R&D objectives relative to JSOP strategy and force objectives levels
2. R&D objectives related to long range projections of JLRSS
3. Rationale to support R&D objectives

20-B PPGM <u>Planning and Programming Guidance Memorandum</u>

This is the guidance supplied by the SECDEF with fiscal levels to be used by each service in their planning. It provides the Total Obligational Authority (TOA) to be programmed by each service for each year in the programming window - 5 years. It also discusses "fences" or programs which are to be protected by funding in certain specified amounts during the cycle. In recent years, the guidance has been less than the FYDP levels.

20-C CPFG CNO Programming and Fiscal Guidance

The PPGM is the base for the CNO allocation of TOA to each mission for the current cycle. It is also the base for assigning funds to each resource sponsor in fulfilling the missions. His allocation of funds to the sponsors is provided as RAD III. The display is a matrix with the ten missions down the page and the 11 resource areas across the page. The total funds for the Sea Control mission are comprised of the portion attributable to each resource such as surface ships, C^3 (Command, Control and Communications), manpower, etc.

20-D SUM CPAM I Summary CPAM I

This document contains the published results and findings regarding the health of the Navy mission areas as presented in the CPAM briefings to the CEB and PDRC. It provides the CNO with background material for issuing his fiscally constrained guidance.

19-A SPP Sponsor Program Proposals

Once the CNO issues his guidance and allocates funding to the sponsors, they prepare proposals which seek to provide adequate resources to support each mission. Since all ten missions must be supported in some way, there are obviously differences with regard to the proper support each mission should receive among the sponsors. This debate is carried on using the PDRC as a forum. During these reviews an attempt is made to achieve program balance by trade-offs between mission funding and between appropriations.

19-B SUM CPAM II Summary CPAM II

This is a published summary of the sponsor program proposals and the decisions recommended by the PDRC. It is used as a base for CNO final decisions on the program.

18-A TPOM Tentative Program Objectives Memeoranda

This document represents the CNO submission of the Navy program for review by the SECNAV. This review is carried out by the Comptrolier of the Navy and the Director, Office of Program Appraisal who look for financial feasibility and balance, reasonablness of cost estimating and conformance to SECNAV and SECDEF guidance. With the signature of the Secretary of the Navy, the TPOM becomes the official program or POM of the Navy.

8-B Program Adjustment Process

This is the final process of allocating funds to each mission, resource area and appropriation based on final guidance of the CNO. These revisions are made by OP-090, the coordination group for programs in OPNAV. The "end game", as it is referred to, is an assignment of funding levels to each area based on a balanced program specified by CNO in CPFG II.

18-C CPFG II <u>CNO Planning and Fiscal Guidance II</u>

This is the final decision by CNO regarding programs to be included in the current POM. The decisions are based on recommendations of the PDRC in Summary CPAM II and provide guidance to OP-90 for final POM preparation.

17-A JFM <u>Joint Forces Memorandum</u>

The Joint Chiefs respond to the PPGM issued by the SECDEF with the JFM. It is a "balancing" document to the POM which is the Service-originated response to the PPGM. The JFM provides recommendations of force levels given the fiscal constraints enumerated by the SECDEF. It discusses force levels, probabilities and risks associated with projected levels at current funding rates. It compares fiscally constrained levels with both JSOP II Prudent Risk levels and FYDP levels. Out of this comparison, issues and discussion areas are suggested for future consideration by SECDEF. It covers the budget year plus seven years in its analysis.

17-B JSCP <u>Joint Strategic Capabilities Plan</u>

The JSCP provides the CINC of the Unified and Specified Commands and the Heads of the Services with direction for the performance of short-range military activities. It is a two part document with Volume I covering:

1. National Security Military Objectives
2. Global and Regional appraisals and strategy
3. Assignment of tasks to CINCS
4. Planning guidance to services

Volume II covers:

1. Force assignments
2. Planning guidance for each functional area, i.e., intelligence, logistics, etc.

The JSCP is published bi-annually and updated as necessary.

17-C FYDP/RAD IV

The Navy POM, being the official program of the current cycle is worked into the FYDP. This version of the FYDP becomes the RAD IV iteration. The program review and decisions of OSD are supported by this version of the RAD.

17-D PR Program Review

The SECDEF, upon receipt of the service POM, initiates a joint OSD/JCS review. Each service program is checked for compliance to guidance, feasibility, reasonablness of costs, risk criteria, etc. The review develops a final rationale for the total Defense program and surfaces issues requiring decision before the budget becomes complete.

17-E POM Program Objective Memorandum

This is the final and official program presented by the Navy to OSD. It is comprised of some 10 volumes of procurement, force structures and levels, manpower requirements, etc. for the program years with cost

levels applied to the first 5 years.

17-F

NAVCOMPT Budget Call

As has been mentioned, the POM covers 8 years of force levels and 5 years of dollar levels. The budget addresses the first year of the five in the POM. The budget cycle picks up from the programming cycle with the NAVCOMPT Budget Call. This is a letter with enclosures which discusses substantive financial matters relative to the budget to be prepared. The call usually reviews the budget formulation cycle, schedules events with dates and refers to the POM for pertinent program information.

16-A

Preparation of NAVCOMPT Budget

Based on NAVCOMPT guidance, POM data and current PDM information, the syscoms and other claimants prepare their proposed budgets. The controls used, if not specified in the guidance, would be the POM TOA levels. The Ship Cost Adjustment Report, a semi-annual exercise, supplies updated costs for each program. Each claimant prepares budget appropriation requests for their area of responsibility. Budget Forms P-1 through P-42 are prepared as applicable. Before the budget is finally signed by the Commander or Director of a component, it has gone through a rigorous schedule of reviews, approvals, panels and boards. The budget, when complete, is submitted to the Office of the Comptroller (OBR/FMR).

15-A PDM Program Decision Memoranda

The Program Review by OSD/JCS develops certain issues which require resolution. The decision made by the SECDEF are published as Program Decision Memoranda. They give the background of the issue, the options considered and the decision made. Assessments are made as to the risk associated with the options and the final decision.

15-B NBM NAVCOMPT Budget Mark

Once the hearings are concluded and controversial issues discussed, decisions are made by NAVCOMPT with regard to the budget. Programs may be reduced, cut, increased, etc. The decisions are published in the format of the original budget with "mark up" notations. The decisions of NAVCOMPT are sent back to the Bureaus, Syscoms and other components. The chief result of the "budget mark" is the publishing of new control figures.

15-C NH NAVCOMPT Hearing

Once the budget has been received from the Syscoms or other claimants and reviewed by OBR/FMD, hearings are held in the Comptroller's Office. These hearings are a forum to debate NAVCOMPT views of budget issues vs. views of the claimants. A typical hearing on SCN issues have been attended by the Head of OBR/FMD,

OP-090, the cognizant program and appropriation sponsors, the responsible SHAPM. These hearings do not solve all the issues, however, and the "budget mark" which follows this process represents the views of NAVCOMPT - not necessarily unanimous views of all parties including claimants.

15-D PBA Prepare Budget Appeals

The Budget Mark identifies areas of controversy between NAVCOMPT and the claimants. The claimants prepare appeals therefore to be taken to higher authority. Initially, this higher authority is OP-90.

14-A APDM Amended Program Decision Memoranda

At the conclusion of the reclama process and the issue meetings, the SECDEF and the Service Chiefs agree on the overall defense program. The decisions made on previously controversial issues are published as Amended Program Decision Memoranda which taken along with the POM are the program of the Navy.

14-B Reclamas

The decisions of the SECDEF, PDM's, are issued to claimant components for review. Those claimants wishing to do so may appeal the decision and request reinstatement of a program. This process is referred to as the reclama. It is a series of sessions at the close of

the programming cycle where claimants appeal decisions of the Secretary.

14-C PDM Issue Meeting

The appeals of the SECDEF PDM leave issues unresolved with regard to the current program. Issues of this sort are resolved for each service's program by a head-to-head meeting between the SECDEF and the Service Chief. Either agreement is reached on an issue or the SECDEF makes the final decision of the program. These decisions are issued as APDM's.

14-D OSD Budget Guidance

When the Program Review of all Service POM's has progressed to the PDM and Reclama stage, enough information is available about the approved program that Budget Guidance can be issued. In addition to certain program decisions per the PDM's, a new Navy TOA control is issued.

14-E Balance to OSD Guidance

The series of hearings concluding with the CNO review has produced a Navy program with appropriation controls based on the original submissions, and Navy guidance. Once the OSD control is issued with its Guidance, NAVCOMPT makes decisions directed toward balancing with OSD. Meetings are held, whether the Navy

is over or under the controls, so that appropriation sponsors and other interested parties can add back or delete programs based on their priority list.

14-F

CNO Hearing

Issues that remain unresolved after the OP-90 hearing are taken by the Head of OP-90 to the CNO for decision. His decisions are in concert with OSD guidance where applicable and where not related, reflect the Navy position for the final submission.

14-G

OP-90 Hearing

The issues developed in the NAVCOMPT Mark and appeals developed by the claimants are reviewed in hearings held by OP-090. Sponsors for programs and appropriations debate with NAVCOMPT on the budget issues. OP-090 judges the merits of each side's argument and makes a decision. If no decision is possible, the Head of OP-090 takes the issue to higher authority.

13-A

SECNAV Budget Hearing

The final Navy decisions regarding budget issues are made in the SECNAV budget hearing. The CNO defends prior decisions and provides the background information on the budget cycle. SECNAV has been kept up to date throughout the budget process, so no big surprises or unresolved issues appear at this point. When the SECNAV

review is complete, the Syscoms are given the go ahead to prepare the final Navy budget.

13-B NAVCOMPT Review

The OSD budget submission, once it has been prepared by the claimants, is reviewed by NAVCOMPT. The primary budget documents, i.e. P-1's are forwarded to OSD for the Program Budget Review. Other back-up documents are kept for a time, checked and used to prepare for testimony at a later date.

13-C Preparation of OSD Budget

All budget issues are resolved by the end of the SECNAV review. New controls have been sent out, NAVCOMPT has issued final program guidance and given the signal, the claimants prepare the OSD Budget submissions. All budget documents are re-worked and budget supplements are prepared. These budget supplements include the Program and Financing Statements (Obligation Phasing Plan), the Congressional Data Sheets and the Five Year Shipbuilding program. These are prepared in a short period of time, generally, and are sent to NAVCOMPT for their final review.

12-A FYDP FYDP/RAD I

The decisions made in the final stages of the programming cycle along with the POM are entered into the FYDP. Additionally, the

NAVCOMPT budget submission to OSD is recorded. This completes the programming cycle.

12-B Program Budget Review

The SECDEF and his staff review budget issues that have been brought to light during the OSD/OMB reviews and which have been developed by OSD staff analysts throughout the budget process. Matters requiring decision are aired during the review process and, at the end, the decisions are published in the form of Program Budget Decisions, the Secretary's thinking on matters is communicated to the Services by Preliminary PBD's so that reclamas can be prepared should the Service so desire.

12-C OSD/OMB Hearings

The Navy Budget, along with the budgets of other Services are submitted to OSD for a continued DOD review. Since the final stages of budget approval occur during a short period of time, this review is carried on jointly by OSD and OMB. The purpose of this review is two-fold.

1. To review the combined service submission and check for overall feasibility, consistancy, reasonableness, etc. and

2. To review the total Defense Budget along with the submissions

of other government agencies and departments. Their review results in issues being surfoced for SECDEF review in the PBD process.

11-A

Issues PBD

The decisions mode by SECDEF with regard to major issues are published in the form of Program Budget Decisions. They are sent to the claimants who have a short amount of time to respond in the form of reclamas, The PBD describes the issue involved, the alternatives considered, and the alternative chosen.

10-A

Final PBD

Having concluded the reclama sessions and the issue meetings with the Service Heads, the final PBD's are issued. Their decisions taken along with the approved budget become the Defense portion of the President's Budget.

10-B

Issue Meeting

The PBD's document SECDEF decisions about major budget issues. The reclamas are the forum for debating issues. The Issue Meeting is a head to head meeting between the SECDEF and the Service Head to agree on final direction. Either agreement is reached, or SECDEF decides the course of action to be taken.

10-C

Reclamas

The decisions of the SECDEF in the PBD's can be appealed by the Services. The debate related to these major budget issues is

referred to as a reclama. No decisions are made at this point -- only discussion designed to adequately present all sides of an issue.

9-A Publish President's Budget

9-B FYDP FYDP Update

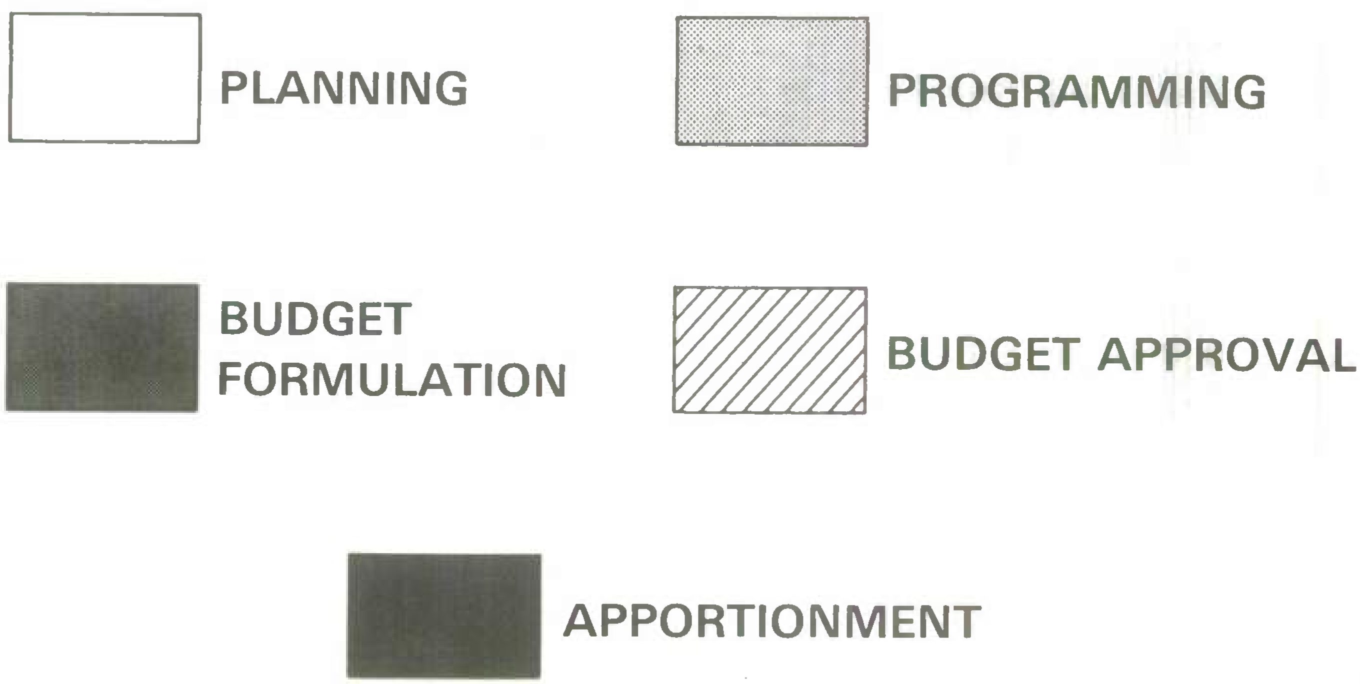
The final Defense budget as amended by the PBD's is input to the FYDP update. The status of the FYDP after the update is the "Approved Program" version.

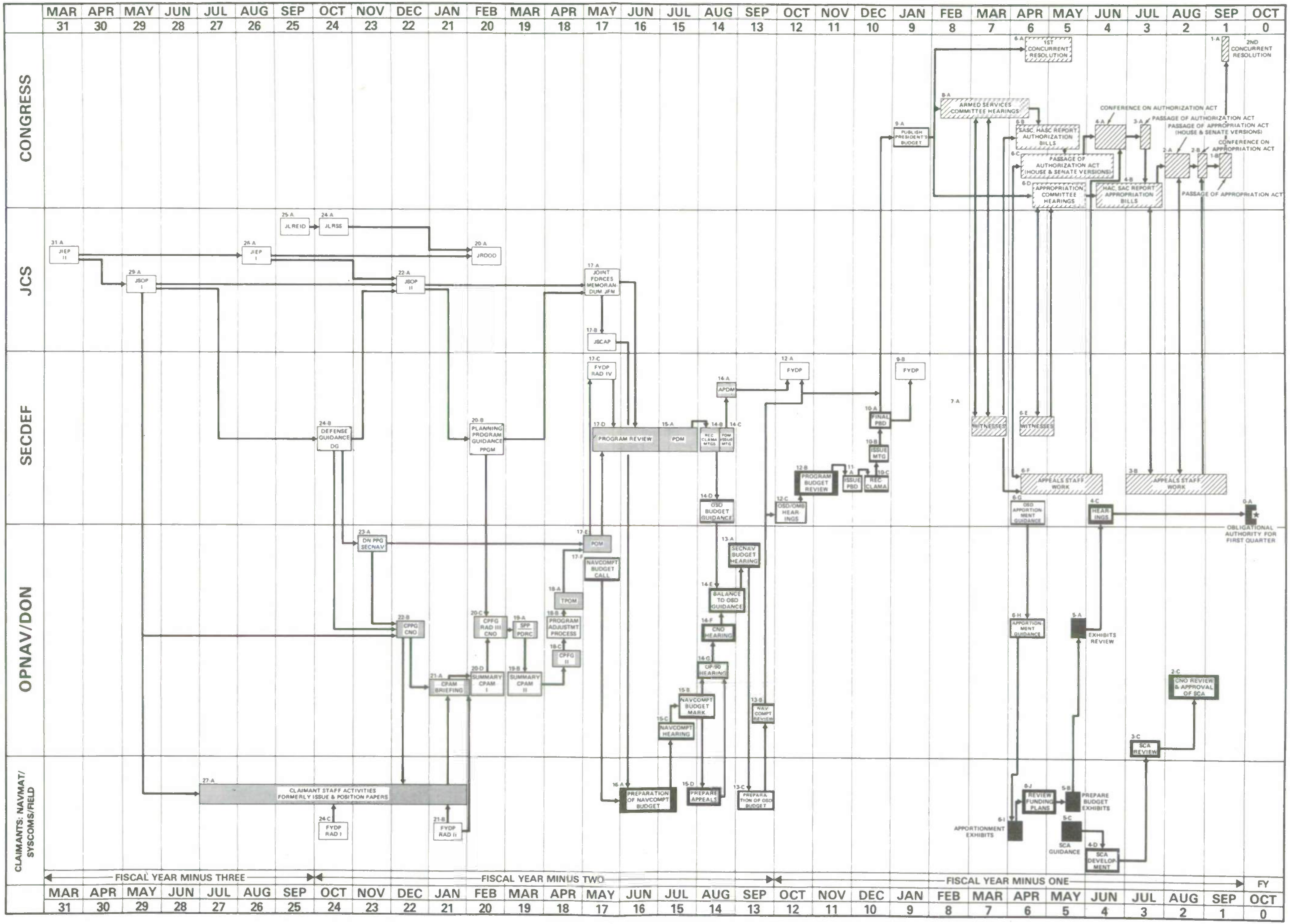
NOTE: All activities carried on in the last nine months of the planning and funding process is carried on in Congress for all Government Departments -- not only the Defense Department. The one exception is the activity ot apportionment where the Executive Branch of the Government is responsible for preparing both the funding levels and timing of approved funds.

FIGURE C.3

THE DOD/NAVY PLANNING, PROGRAMMING AND BUDGETING SYSTEM

SINGLE CYCLE FORMAT





CONGRESS
JCS
SECDEF
OPNAV/DON
CLAIMANTS: NAVMAT/SYSCOMS/FIELD
FISCAL YEAR MINUS THREE
FISCAL YEAR MINUS TWO
FISCAL YEAR MINUS ONE
FY
1ST CONCURRENT RESOLUTION
2ND CONCURRENT RESOLUTION
ARMED SERVICES COMMITTEE HEARINGS
SASC, HASC REPORT AUTHORIZATION BILLS
PASSAGE OF AUTHORIZATION ACT (HOUSE & SENATE VERSIONS)
APPROPRIATION COMMITTEE HEARINGS
HAC, SAC REPORT APPROPRIATION BILLS
CONFERENCE ON AUTHORIZATION ACT
PASSAGE OF AUTHORIZATION ACT
PASSAGE OF APPROPRIATION ACT (HOUSE & SENATE VERSIONS)
CONFERENCE ON APPROPRIATION ACT
PASSAGE OF APPROPRIATION ACT
PUBLISH PRESIDENT'S BUDGET
JIEP II
JIEP I
JLREID
JLRSS
JRDOD
JSOP I
JSOP II
JOINT FORCES MEMORANDUM JFM
JSCAP
FYDP RAD IV
DEFENSE GUIDANCE DG
PLANNING PROGRAM GUIDANCE PPGM
PROGRAM REVIEW
POM
REC CLAMA MTGS
POM ISSUE MTG
APDM
FYDP
OSD BUDGET GUIDANCE
OSD/OMB HEARINGS
PROGRAM BUDGET REVIEW
ISSUE PBD
REC CLAMA
ISSUE MTG
FINAL PBD
WITNESSES
APPEALS STAFF WORK
OSD APPORTIONMENT GUIDANCE
HEARINGS
OBLIGATIONAL AUTHORITY FOR FIRST QUARTER
DN PPG SECNAV
POM
NAVCOMPT BUDGET CALL
TPOM
PROGRAM ADJUSTMT PROCESS
CPFG II
CPFG RAD III CNO
SPP PORC
SUMMARY CPAM I
SUMMARY CPAM II
CPPG CNO
CPAM BRIEFING
SECNAV BUDGET HEARING
BALANCE TO OSD GUIDANCE
CNO HEARING
OP-90 HEARING
NAVCOMPT BUDGET MARK
NAVCOMPT HEARING
NAV COMPT REVIEW
APPORTIONMENT GUIDANCE
EXHIBITS REVIEW
CNO REVIEW & APPROVAL OF SCA
SCA REVIEW
CLAIMANT STAFF ACTIVITIES FORMERLY ISSUE & POSITION PAPERS
FYDP RAD I
FYDP RAD II
PREPARATION OF NAVCOMPT BUDGET
PREPARE APPEALS
PREPARATION OF OSD BUDGET
APPORTIONMENT EXHIBITS
REVIEW FUNDING PLANS
PREPARE BUDGET EXHIBITS
SCA GUIDANCE
SCA DEVELOPMENT

IV. PHASED ACQUISITION SYSTEM CHART AND DETAILED DESCRIPTION OF ACTIVITIES

The Navy Ship Acquisition Process was developed by DOD in 1972 as a method for managing Defense acquisition programs. Descriptions of the basic activities concerned with Planning, Funding, Control, and Evaluation are provided. The process involves the entire procedure of acquisition, beginning with identification of system requirements through final delivery of the ship.

The process is divided into seven distinct phases as follows:

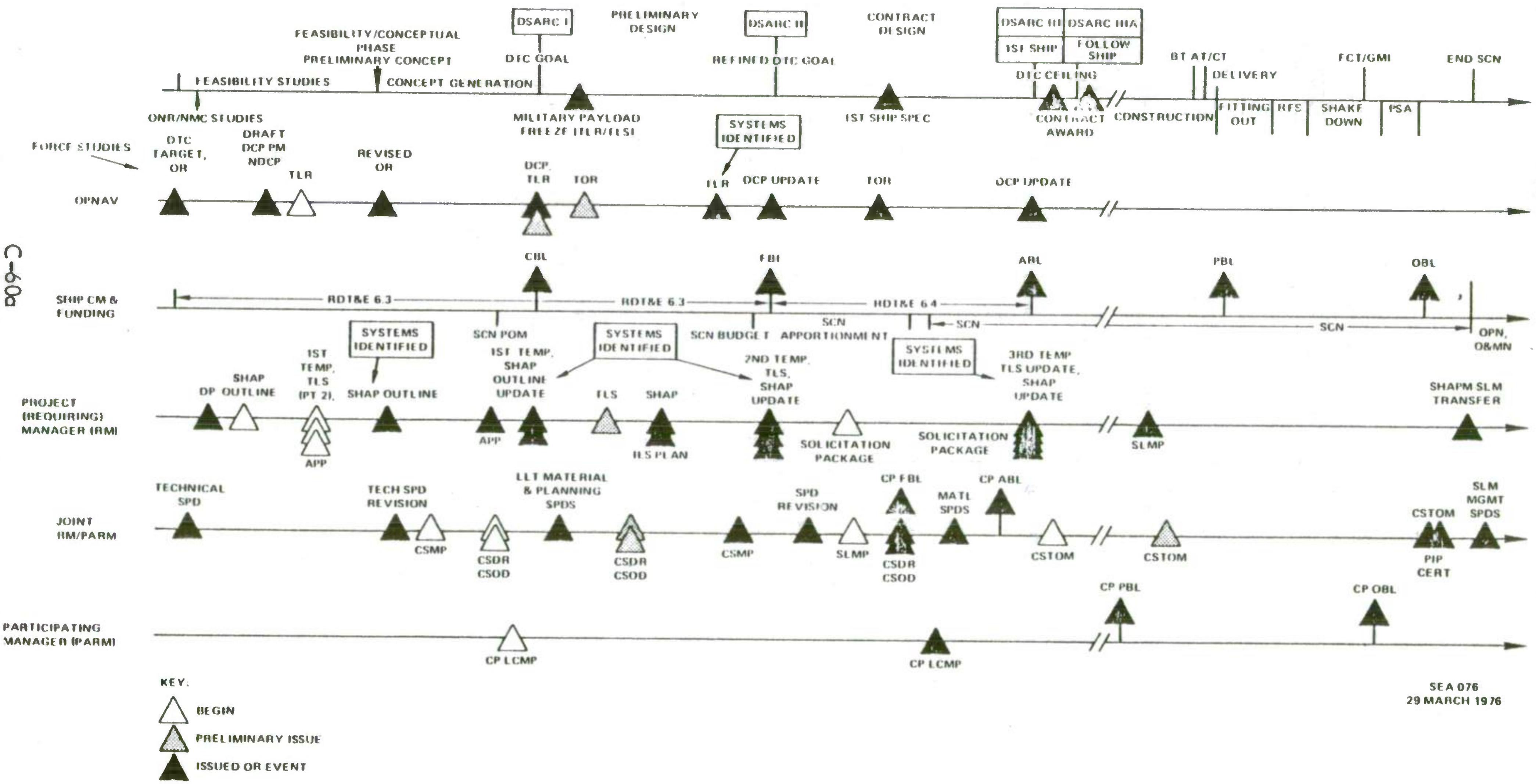
1) Origination of Ship's Requirement
2) Validation of Ship's Requirement
3) Conceptual Design
4) Preliminary Design
5) Contract Design
6) Detailed Design and Construction of Lead Ship
7) Production of Follow Ships

These seven phases plus the Operational Phase, through decommissioning are detailed in the Figure (Figure C.4) at the end of this section. Each box on the figure is numerically keyed to the narrative which precedes the Figure. As an overview, a brief version of the acquisition process is shown on the next page.

FIGURE C-4

COMBATANT SHIP ACQUISITION EVENT PHASING AND SYNCHRONIZATION

(REPRESENTATIVE)



1. ORIGINATION OF REQUIREMENT

1-A PLANNING PROCESS OF THE JOINT CHIEFS OF STAFF

The Joint Chiefs of Staff identify possible needs for new force structures by considering national objectives, treaty obligations, current equipment inventories, and apparent deficiencies. Their planning process results in the issuance of a Five Year Defense Plan. In a general way, this process sets the stage for ship requirements.

1-B NAVAL OPERATIONS MISSION/RESOURCE SPONSORS

The ship acquisition process begins with consideration of national objectives, policies, projections of economic conditions, psychological attitudes, and available technology. After the threat is defined and national and military strategies developed, studies of possible alternative trade offs of (1) missions and tactics, (2) technology and (3) available resources; takes place in order to establish necessary operational and technical capabilities.

1-C RESEARCH AND DEVELOPMENT WITHIN THE NAVY

Navy laboratories and other RDT&E organizations play a vital role in development of ships and weapons systems outside the current "state of the art".

1-D GENERAL OPERATIONAL REQUIREMENT

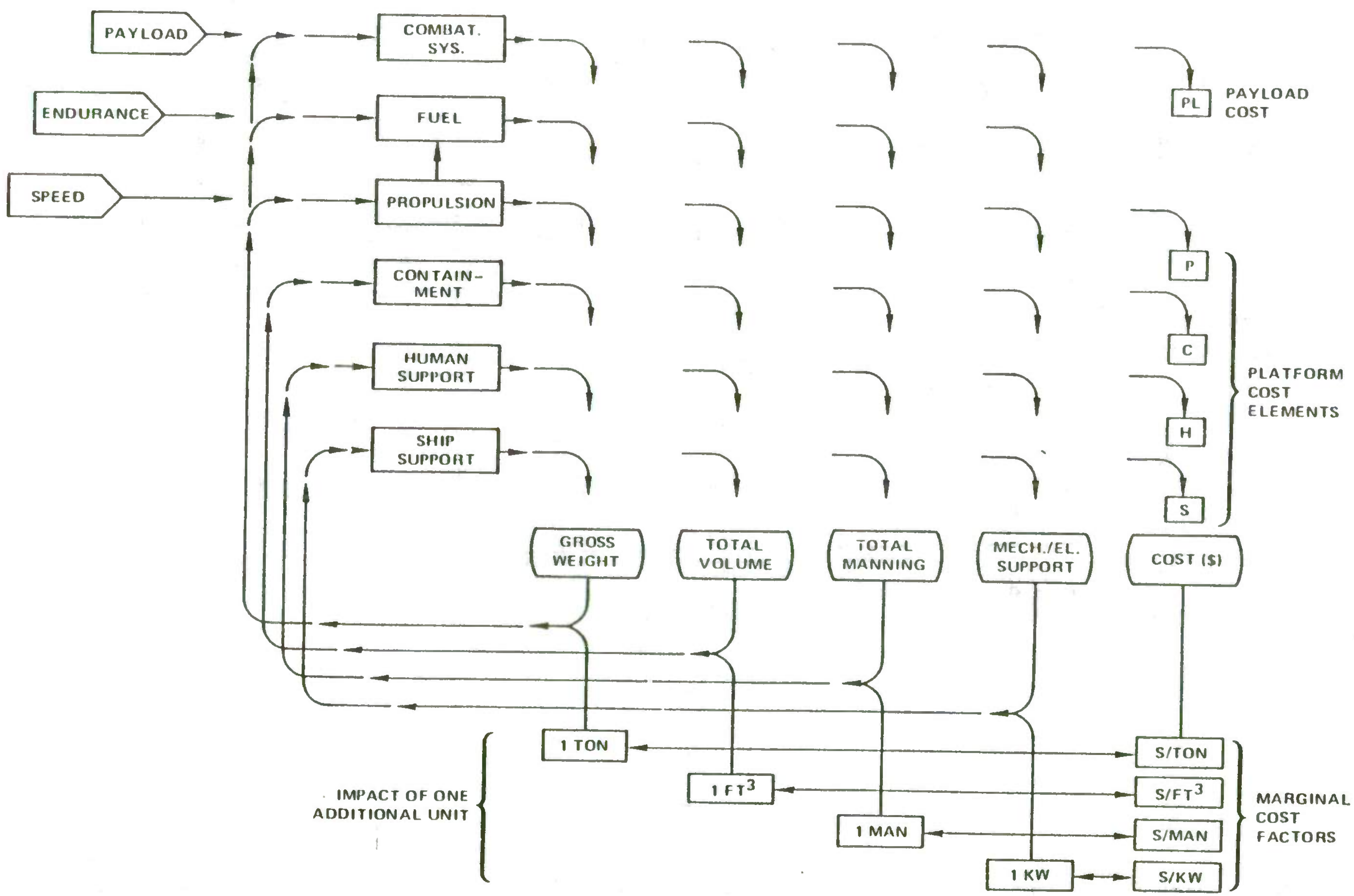
The General Operational Requirement is a broad statement of objectives and goals for operational capabilities that will be required in warfare or support areas to counter anticipated or predicted threats within 10-20 years. It provides guidance for the preparation of Proposed Technical Approaches (PTA) for meeting future needs when required support technology is available (See Figure C.5 for a chart on ship subsystem interdependencies which relates to the generation of the Requirement.)

1-E NAVY LABORATORIES/PRIVATE CONTRACTORS

Government owned and operated laboratories are the main in-house research and development focal points and account for approximately 30 percent of the Navy's RDT&E program.

FIGURE C-5

SHIP SUBSYSTEM INTERDEPENDENCIES



Navy regulations call for RDT&E work to be accomplished by the class or institution - Government laboratories, educational institution or private contractor, who can perform the work most effectively and efficiently.

1-F PROPOSED TECHNICAL APPROACH

The Proposed Technical Approach (PTA) is prepared by the Systems Commands for the use of CNO/CNM. It aids the CNO's decisions regarding further development towards mission accomplishment by providing technical information, cost/trade-off data, and an assessment of the reliability, maintainability and support requirements for systems similar to those under consideration.

II. VALIDATION OF REQUIREMENTS

2-A CNO PROCESS OF OPERATIONAL REQUIREMENT DEVELOPMENT

The CNO, being a part of the JCS, prepares the OR which describes a desired objective, lists alternative approaches, estimated cost parameters, etc. The CNO also convenes the Ship Acquisition and Improvement Panel (SAIP) which, after a review of the requirement, appoints an appropriate Program Coordinating Committee to assist in preparing the Top Level Requirement. Further, the CNO appoints the SHAPM.

2-B OPNAV SPONSORS

OPNAV establishes the mission requirements for the acquisition and specifies these in the Operational Requirement (OR). This document essentially expresses the need for a particular capability in a system or equipment.

2-C CNO EXECUTIVE BOARD

The CNO Executive Board advises the CNO on strategy, policy and programs, and assists in the analysis of decision alternatives. The CEB has several special panels including the Ship Acquisition and Improvement Panel referred to in 2-D.

2-D SHIP ACQUISITION AND IMPROVEMENT PANEL

The SAIP is responsible for developing, monitoring and controlling the characteristics of all ships, floating dry docks, landing and service craft and large and medium labor tugs and patrol craft.

Upon definition of mission and requirements by the CNO, the Ship Acquisition and Improvement Panel (OP-03) begins ship program studies and the processing for Conceptual Baseline documents. Coordinating with personnel from the Systems Analysis Division, CNM, and DCNO for RDT&E, the chairman of the SAIP initiates development of the Top Level Requirement document (TLR).

2-E DISCUSSION OF MISSION REQUIREMENTS AND ALTERNATIVE APPROACHES

The SHAPM maintains communications channels open to OPNAV, CNM, PARMs, and NAVSEA functional organizations to ensure that the mission requirements are clearly understood. In addition, the effective use of these channels will serve to reduce the possibility of redundency in required tasks.

2-F FYDP EXTENDED PLANNING ANNEXES

The Extended Planning Annex is a detailed listing of specific resource requirements of the five-year defense programs.

CNO DECISION ON SHIP/SYSTEM

Once optional systems and approaches have been decided on, the CNO selects a system for further development with guidance as to implementation.

2-H PUBLISH OPERATIONAL REQUIREMENT

The CNO issues the Operational Requirement (OR) which serves as the basic document for Navy programs requiring development activity. This initial document often establishes a Design-to-Cost target developed with the assistance of NAVSEA 01G.

III. CONCEPT PHASE

3-A SHIP ACQUISITION AND IMPROVEMENT PANEL APPOINT PROGRAM COORDINATING COMMITTEE

The SAIP appoints the Program Coordinating Committee whose mission is to assist in the development and coordination of the Top Level Requirement and Top Level Specifications.

3-B CNO APPOINTS SHAPM

The SHAPM is appointed and functions under a Charter, approved by the Chief of Naval Material, from the Commander, Naval Sea Systems Command. The SHAPM is the manager for development, design and construction of an assigned ship program.

3-C PROGRAM COORDINATING COMMITTEE DEVELOPS TLR/TLS

This group includes representatives from participating activities who assist the Program Coordinator (OPNAV) in developing and coordinating Top Level Requirements and Specifications.

The TLR defines the operational requirements for the ship in qualitative terms. The maximum cost and all program constraints which can affect ship design and utilization are specified. The TLR is generated through a cooperative effort between the CNO and CNM.

Top Level Specifications, developed by NAVSEASYSCOM, converts the top level requirement into a physical ship description. The TLS is generated in conjunction with the TLR, but is issued after the TLR at the end of preliminary design.

3-D SHAPM BEGINS DEVELOPMENT ACTIVITIES

Managing a Ship Program is similar to setting up a large company and sometimes is equivalent to a small industry. A number of activities, therefore, are required up-front including staffing, procedures, financing, space, etc.

3-E PREPARE DEVELOPMENT PROPOSAL

The Development Proposal is prepared as a response to the Operational Requirements document and comments on the feasibility of and the cost to produce a ship which can accomplish the stated mission. It will also discuss the alternative means of mission accomplishment considered.

3-F PREPARE CSMP

The Combat System Management Plan is the primary management document used in planning combat system integration activities. It specifies functional work areas to be covered by Participating Managers and provides guidance for the Combat System Design Requirement (CSDR), test site planning, the combat system testing plan, configuration management, life cycle support and documentation requirements.

3-G PREPARE TEMP

The Test and Evaluation Master Plan (TEMP) provides test and evaluation guidance for ship systems and equipments. This document is prepared by the SHAPM and is reviewed during the DSARC process. It supports the TLR and TLS and may be updated as more definitive data becomes available.

3-H PREPARE APP

The Advance Procurement Plan is the principal long-range procurement planning document for items needing to be ordered prior to start of the construction period. It identifies the long-range operational, technical, business and policy considerations essential to orderly and economic procurement actions.

3-I PREPARE SHAP OUTLINE

The SHAP outline describes actions to be taken and milestones to be met during the acquisition process along with the rationale for planned activities. This outline evolves into the official SHAP as more definitive information becomes available. Some specific areas addressed in this document include: (1) physical and performance characteristics; (2) plans for contract definition, procurement, production; (3) operational and logistic maintenance support; (4) milestone completion dates, etc.

3-J ACTIVATE SHIP PROJECT DIRECTIVE MACHINERY

The Ship Project Directive is essentially a contract between the SHAPM and PARM's - the providers of the goods and services necessary to accomplish the project effort planned. SPD's may

be separated into four types: (1) Technical Support, (2) Advance Material Procurement, (3) Planning Material, and (4) Regular Material SPD's.

3-K CNO REVIEW OF DEVELOPMENT PROPOSAL

The Development Proposal presents to the CNO the following: (1) the results of technical studies and (2) alternative solutions to a given problem. In other words, the CNO is presented with all the information necessary to make operational and cost effective comparisons between all possible technical solutions.

The DP also presents to the CNO a discussion of the operational need, the program objectives, and the recommended CNM solution.

3-L TLR/TLS DEVELOP TO CONCEPTUAL BASELINE

During the conceptual phase, alternatives are examined for possible cost and characteristic trade-offs. Once the alternatives (Feasibility Studies) are compared and an alternative is selected which provides the proper balance between operational requirements and cost, the design documentation becomes the conceptual baseline. The conceptual baseline is the basis for the preliminary design.

3-M PERTINENT DATA FOR DCP OR PM-DSARC PRESENTATIONS

The pertinent prerequisites for DSARC Reviews are:

(1) The "For Coordination" draft DCP - the "initial" draft DCP after review within OSD and other interested groups.
(2) Evaluation report of the test program by the DDR&E (T&E)
(3) Report by the Cost Analysis Improvement Group on their evaluation of the service cost estimates.

3-N CNO PREPARES PROPOSAL MEMORANDUM (ACAT II)

A Proposal Memorandum (PM) is prepared for Acquisition Category II programs which have estimated expenditures less than $75 million RDT&E funds or less than $300 million procurement funds. Guidance for PM preparation is found in the Navy Programming Manual and related documents. The draft PM is presented to the DNSARC at two months prior and two weeks prior to each scheduled DSARC review.

3-O CNO PREPARES DECISION COORDINATING PAPER (ACAT I)

The Decision Coordinating Paper (DCP) is prepared for Acquisition Category I programs which have estimated expenditures exceeding $75 million RDT&E funds or exceeding $300 million procurement funds. Guidance for preparation is found in the Navy Programming Manual and related documents. It is a summary that provides management with a broad overview of a major program, supporting both the DSARC review and SECDEF decision-making process.

3-P DSARC PROCESS

The DSARC I leads to the Program Initiation Decision. Many issues are discussed during the proceedings such as:

(1) potential military need
(2) military requirements related to the mission, threat, etc.
(3) definition of mission/performance requirements
(4) identify major risks and problems
(5) establishment of realistic quantity, resource, schedule, and cost estimates (Class "D" quality)
(6) economic and technical competition
(7) appropriate DCP threshholds
(8) alternate "fall-back" position
(9) design to cost goals
(10) test objectives

After approval at DSARC I, negotiations can begin on Long Lead Time Material and Planning SPD's.

3-Q DCP - SECDEF APPROVED

The SECDEF first decision is the Program Initiation Decision point after DSARC I. The decision point is planned to occur before obligation of large expenditures for development and before possible program alternatives have been abandoned. SECDEF is concerned with the areas discussed in DSARC I and recommendations incorporated into the DCP. The primary concerns are: (1) proven identified need; (2) system parameters fulfill the need; (3) proper plan established to evaluate system alternatives; (4) reasonable estimates of preliminary costs and scheduling; (5) adequate test and evaluation plans; (6) acquisition strategy is in line with program characteristics.

IV. PRELIMINARY DESIGN

4-A PREPARE ILS

The Integrated Logistic Support Plan is a composite of the elements necessary to assure that the maintenance needs of the ships and systems delivered to the fleet are anticipated and that the resources are available to meet such needs. Its purpose is to promote the development of technically adequate hardware which is cost effective, reliable, maintainable and supportable.

4-B DEVELOP TACTICAL OPERATIONAL REQUIREMENT

The Tactical Operational Requirements is a high level document for the projected implementation of an integrated combat system, supporting the TLR and TLS in the area of combat systems.

4-C MILITARY PAYLOAD FREEZE

Militcry Payload Freeze occurs when CNO and the SHAPM are agreed that TLR/TLS identification of the elements of the ships payload system go under formal configuration management.

4-D PREPARE PRELIMINARY CSOR

Based upon the combat system design, the Combat System Operational Requirement provides the procedures necessary to assure integration of subsystem computer programs with each other and also with the overall combat system.

4-E ISSUE FINAL CSMP

The Combat System Management Plan outlines activities necessary to implement the combat systems aspect of the ship acquisition process, including computer programs. The CSMP aids inter PARM communication and agreement, and also provides a common basis for combat system SPD's.

4-F PREPARE PRELIMINARY CSDR

The Combat System Design Requirement document describes the overall combat system, provides a description of system functions and capabilities, interface/functional flow/operational sequence diagrams, along with software guidelines and constraints.

4-G ISSUE PRELIMINARY TEMP

TEMP is issued to all pertinent organizations for information and comment.

4-H ISSUE PRELIMINARY SHAP

Same as above.

4-I TRL/TRS DEVELOP TO FUNCTIONAL BASELINE

The TLR and TLS reflects the Functional Baseline which contains functional and interface characteristics, design constraints and tests required to demonstrate the achievement of the functional characteristics. During the Preliminary Design Phase, the TLR and TLS are concurrently developed from preliminary to final form for issue at the DSARC II decision point.

4-J PERTINENT DATA FOR DCP OR PM DSARC PRESENTATIONS

Same format as DCP, PM and DSARC I.

4-K DCP DRAFT

Same as above.

4-L DSARC PROCESS - DSARC II APPROVAL FOR FULL SCALE DEVELOPMENT

The DSARC II review leads to a decision on full-scale engineering development. Some of the issues and questions involved at this review are:

(1) Does the defense system still satisfy military need, mission, threat and anticipated resources?
(2) Is there a proper balance between cost (Class "C" quality estimate), schedule, and performance?
(3) Are quantity, resource and schedule estimates practical and reasonable?
(4) Are major uncertainties reduced to tolerable levels?
(5) Establishment of valid design-to-cost guidelines accomplished?
(6) Are well defined DCP threshholds established?
(7) Have there been satisfactory development and operational test and evaluations up to DSARC II?
(8) Establishment of integrated test and evaluation plan.
(9) Reassessment of proposed alternative positions.

At the DSARC II decision point, the TLS (Top Level Specification), second TEMP (Test and Evaluation Master Plan), and an updated SHAP can be issued.

4-M DCP/SECDEF APPROVED

The second decision point for the SECDEF after DSARC II is the Full-scale Engineering Development Decision Point. At this stage of the program SECDEF decides whether resources should be committed to full-scale engineering development or to detail design of the defense system. The SECDEF makes his decision on the basis of updated information, in the DCP such as: (1) reaffirming the operational need; (2) readiness of the program to proceed; (3) adequacy of test and evaluation approach, and results thus far, and (4) revalidation of cost and schedule estimates, etc.

V. CONTRACT DESIGN

5-A TLR/TLS ARRIVE AT ALLOCATED BASELINE

The TLS is updated during the Contract Design Phase to reflect the requirements in the contract specifications and is issued before the DSARC III decision point. It becomes the documentation reflecting what CNM will supply to meet the Technical Operational Requirements. No OPNAV initiated program changes should be made without a formal change to the TLS and TLR; thus an audit trail is provided for uncontrolled cost increases. See Figure C.6 for a flow chart on ship requirements - specifications from feasibility studies through contract design.

5-B PREPARE BID SPECIFICATIONS

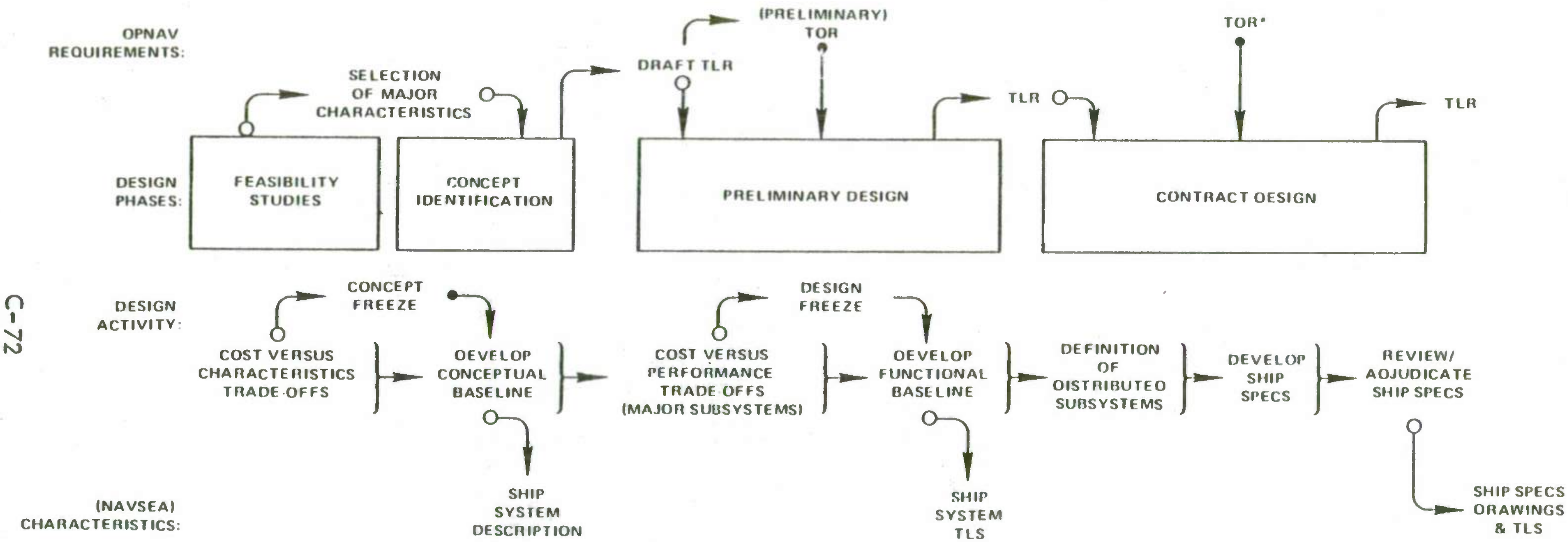
NAVSEC, PARMS, and NAVSEA functional organizations aid the SHAPM in the preparation of drawings, specifications and plans for the bid package.

5-C PREPARE QUALIFIED BIDDERS LIST

The project manager requests preparation of the Qualified Bidders List. The list is derived from the Master Bidder's Mailing List for the particular type of ship involved. Other firms known to have an interest, but not presently on the master list can be included. Then the qualifications of each firm are examined against the proposed project requirements: technical requirements, quantities, and special contractual considerations involved in the procurement. Those which qualify, remain on the Qualified Bidders List.

FIGURE C.6

REQUIREMENTS — SPECIFICATIONS DIALOGUE



*TOR – COMBAT SYSTEM TACTICAL OPERATIONAL REQUIREMENT, SECNAVINST 3560.1

5-D PREPARE RFP

The RFP (Request for Proposals) is a formal solicitation, and includes a package of material sent to the prospective bidder's including contract terms, solicitation instructions and conditions, information to offerors, representation required of the offeror, unit price analysis - basic contruction (NAVSHIP form 4280.2), and contract specifications, drawings, etc.

5-E REVIEW BY SUPSHIPS

The Supervisor of Shipbuilding at a probable building yard generally reviews the bid package and provides input related to the ability of a potential contractor to produce the end product.

5-F PREPARE CONTRACT DATA REQUIREMENTS

The SHAPM, assisted by NAVSEA 046 (Logistics Support Programs Division) will prepare the Contract Data Requirements List, which specifies data to be provided related to the shipbuilding and vendor contracts (GFM).

5-G PREPARE PROGRAM INTEGRATION PACKAGE (PIP)

This package consists of the System Operational Design for the Combat System, Interface Design Specifications, Program Documentation Markup, and Design Analysis and Review Task Group Proceedings. The PIP eventually becomes the post SCN combat system computer program integration configuration control package.

5-H PREPARE SLMP

The Ship Logistic Management Plan implements or identifies actions, responsibilities, budgeted funds, training and maintenance required to properly support the ship subsequent to turnover.

5-I FINALIZE CSOR

Incorporate comments from interested groups, make final decisions on combat systems and publish operational requirement.

5-J FINALIZE CSDR

The CSDR described in 4-F is issued at this point of the Contract Design Phase, after sufficient information has been obtained for the issuance of the TOR by OPNAV.

5-K ISSUE TEMP

The Test and Evaluation Master Plan is implemented at this point, following program approach outlined at DSARC II. This may require building, equiping and/or operating land based test sites; selected equipments or systems may be installed aboard exisitng ships for testing.

5-L PROCEED WITH ADVANCE PROCUREMENT OF LONG LEAD ITEMS

The DSARC II decision point should provide authority to pracure long lead time material for the lead ship. The PARM's will negatiate for the lead ship items and make preliminary cantract provisions (fixed price plus escalation) for follow ship material (if later approved). Also the tentative Planning SPD's will be converted to funded documents at this point in time.

5-M ISSUE FINAL SHAP

The issuance and updating of the SHAP shauld be programmed to caincide with budget inputs to the Program Objectives Memorandum. The SHAP outline is replaced by the SHAP as design and development continue and more definitive information becames available. The SHAP outline officially becomes the SHAP at the Preliminary Design Phase.

5-N FUND SPD ACTIVITIES FOR DESIGN AND CONSTRUCTION

Arrangements are made to fund activities necessary for design work (NAVSEC and their subcontractors) and construction (GFM items with PARMS), etc.

5-O DCP DRAFT

Same as above.

5-P DSARC PROCESS DSARC III, APPROVAL FOR DETAIL DESIGN AND CONSTRUCTION - LEAD SHIP (DSARC A, DSARC B)

The DSARC III leads to the production/deployment decision. Many areas discussed at DSARC I and II are updated and additional areas are surfaced such as (1) current evaluation of military need, and performance related to mission, threat, etc.; (2) adequate test results to support start of major production; (3) realistic quantity, resource, and schedule estimates; (4) completion of comparisons between alternative methods of fulfilling the military need; (5) well defined DCP threshholds; (6) valid production quantity requirements; (7) exposure of all major problems; (8) identification of production issues; (9) sound approach to contractor selection; (10) criteria established for future production decisions. The Allocated Baseline (ABL) consisting of performance oriented contract specifications and drawings for development of all shipboard systems, will exist by DSARC III.

Now finalization of a Qualified Bidder's List, solicitation, selection and awarding of the contract for the lead ship is possible.

5-Q DCP - SECDEF APPROVED
As above for same item.

VI. DETAIL DESIGN CONSTRUCTION LEAD SHIP

6-A ISSUE RFP's AND SUPPORTING DATA FOR BID

Once the negotiator, cognizant SHAPM, and the Office of Counsel, are satisfied with the adequacy and accurancy of the information in the RFP and supporting data, then the negotiator coordinates the procedure to issue the solicitation and receive offers.

6-B RECEIVE AND ANALYZE CONTRACTOR REPLIES

The negotiator, cognizant project manager, and the Ship Production Office perform key roles in the source selection procedure. The contractor replies are analyzed to ensure that the prospective contractor is "responsible" according to ASPR 1-903 and that the contractors offer is the most beneficial to the government, considering price and other factors. The NAVSEA source selection team utilizes pre-award surveys, information files, Master Bidder's List, contract performance summaries, completed contract files and individual data submitted by contractor with his offer. The data is analyzed against ASPR 1-903 standards.

6-C CHOOSE CONTRACTOR AND AWARD CONTRACT

Once the analysis above is completed, a contractor will have been chosen and all required clearances need to be obtained. The negotiator assembles the contract file, and contract preparation commences. For formally advertised procurements, the Contracting Officer signs the award and mails it to the offeror, and a legally binding contract takes effect. For negotiated procurements, the government and the offeror must sign the contract for it to be legally binding.

6-D CONTINUOUS COMPONENT/SYSTEMS TEST DURING CONSTRUCTION

During the ship construction period, production acceptance test and evaluation is continually taking place to be sure all systems and equipments installed are in accordance with the contract. An Integrated Test Package is established combining government and shipbuilder prepared test documentation. The Management Plan for Total Ship Test Program for Ship Production is utilized to develop the ITP.

6-E DELIVER LONG LEAD ITEMS FOR LEAD SHIP

Items on order prior to the construction decision are delivered to the contractor for installation in the ship platform.

6-F ORDER LONG LEAD ITEMS FOR FOLLOW SHIPS

After the DSARC III Decision Point and approval of the start of detail design and construction of the lead ship, procurement of long lead time material for the follow ships in the program can commence.

6-G DELIVER GFM AND GFE

When GFE is accepted by the shipbuilder, a signed receipt is forwarded to the SHAPM.

6-H DETAIL DESIGN/CONSTRUCTION LEAD SHIP

1. Engineer Specs for CFM

Otherwise known as "purchase specification," this is a technical description of the item, including characteristics, capacities, materials, etc. This document is prepared by the shipyards's design (or engineering) unit and is a part of the purchase order issued to the vendor.

2. Detailed Hull Design

The working drawings prepared by the shipyard or its design agent which are issued to the yards production department for construction of the ship. The working drawings are translations of the ships specifications and other contract documents.

3. CFM Purchase Contracts

These are contracts with vendors, which are basically "purchase orders." The contracts include the specifications describing the item, requirements for vendor drawings, instruction books, delivery date, etc.

4. Scheduled Material Delivery

The delivery of contractor furnished materials including steel, piping, etc. and GFE, pursuant to the contractors material ordering schedule and construction schedule. The material is scheduled in such a manner as to require minimum storage yet sustain construction.

5. Pre-Keel Fabrication

Construction of the ship is begun with fabrication of steel and piping,and assembly into manageable units, including bottom shell, plating, inter bottom units, etc. A sufficient amount of such work is completed in the pre-keel period to sustain construction after keel laying.

6. Lay Keel

Erection of the first unit in the shipway or building dock, including flat and vertical keel plates.

7. Hull Construction

Erection of the hull in the shipway or building dock, including deck houses requiring heavy lift cranes.

8. Install Machinery, Equipment, Military Systems

Installation of main and auxilliary machinery and weapon systems.

9. Launch

Official launching or christening of the ship, and movement from the shipway or building dock in which it was erected to an outfitting pier.

10. Post Launch Outfitting

Completion of interior work including living and working spaces, communication and navigation systems, weapon systems, etc.

11. Dock Trials and/or fast cruise simulation

Conduct of trials at the dock for purposes of testing main propulsion and auxiliary systems.

12. Builders Sea Trials

Underway trials and inspections conducted by the builder to assure readiness of ship for trials by Navys Board of Inspection and Survey.

13. INSURV Trials

Acceptance of INSURV Trials conducted by Navy Board of Inspection and Survey to determine suitability of ship for Navy acceptance.

14. Correct Deficiency

Correction of deficiencies and completion of incomplete items as determined during sea trials.

15. Deliver to Navy

Official delivery of a ship to the Navy by the shipbuilder.

6-I SHAP CONSTRUCTION MONITORING

SUPSHIP will be primarily responsible for the daily monitoring of the shipbuilder's performance, although the SHAPM and his staff should observe on-site performance periodically.

6-J COMPLETE FITTING OUT PROCESS

This is the process of placing material specified in allowance lists on board the ships. This is accomplished during the Fitting Out Availability period and usually occurs in conjunction with the shipyard work period. The process includes installation, check-out and testing.

6-K DOCUMENT CHANGES TO FOLLOW SHIPS

Plans changed during lead ship construction are brought up to data prior to start of follow ship construction.

6-L SHIP COMMISSIONING

This occurs after delivery and is characterized by the manning of the ship by Naval personnel,and the transfer of responsibility for the ship to the fleet commander.

6-M READY-FOR-SEA PERIOD

This period begins after the fitting out period and lasts from one to three weeks. The RFS period is designed for the Commanding Officer to prepare his command for the shakedown period. All tests, alignments, calibrations, etc. should be completed during this period.

6-N PREPARE REPORT ON TEST AND EVALUATION

Results of all tests are documented and indications as to corrective action accomplished.

6-O UPDATE SLMP

Based on the most up-to-date data on the ship as constructed, the Ship Logistics Management Plan is updated and published for use of personnel responsible during the operational phase.

6-P SHAKEDOWN CRUISE (Shakedown)

The Shakedown period extends from Readiness For Sea to Post Shakedown Availability. The following should be completed during this period: (1) special trials and tests not previously completed; (2) calibration of equipment; (3) alignment of weapon systems; (4) degoussing, ranging, (5) organize the ship and train the crew; (6) load aviation units; (7) refresher training; and (8) final contract trials.

6-Q UPDATE SHAP

The SHAP is generally revised: (1) on a periodic basis not to exceed six months from the issuance of a previous revision; or (2) if major factors alter the project, or (3) if many minor factors begin to alter the project.

6-R PREPARE TRANSFER PACKAGE

About a month before final contract trials, the SHAPM prepares a Transfer Plan and sends it to the appropriate Ship Logistic Manager for review. The Transfer Package outlines the documentation to be turned over to the SLM when he assumes management control. The documentation identifies and details the planned support of the ship (maintenance) during the ships expected life cycle.

6-S POST SHAKEDOWN OVERHAUL

The PSO occurs to correct deficiencies discovered during the shakedown cruise. Contractor and government responsible deficiencies will be corrected as well as any other authorized work.

6-T DCP DRAFT

The DCP will be updated with the results from the DSARC III A decision, (if necessary) and forwarded for SECDEF approval. The decision at this point deals with follow ship construction.

6-U DSARC PROCESS - DSARC III A, [APPROVAL FOR FOLLOW SHIP CONSTRUCTION] (DNSARC A, DNSARC B)

DSARC III A follows the same format and covers the same areas as the DSARC II decision point (committment to full scale development). The data available from the lead ship experience will be incorporated into these proceedings.

6-V DCP SECDEF APPROVED

The SECDEF approves (disapproves) the continuation of SHAPM programs by authorizing the procurement of follow ships.

6-W TURNOVER TO SLM

The Ship Logistic Manager is responsible for fleet support, and overhaul and modernization of ships from the point at which the SHAPM transfers the ships to the SLM. The actual transfer date of a ship is decided by agreement between the SLM and the SHAPM. Subsequent to the transfer, OPN and OMN funds will be used for continued life cycle support of the ship.

VII. Most of the steps in Phase VII: Production Phase - Follow Ships are repeats of the Phase VI - Detail Design Construction of Lead Ship.

7-F CLAIMS NEGOTIATION AND SCHEDULE

According to NAVSEA INST. 4365.1, a team is established for each claim submitted and accepted by NAVSEA, and specific steps for investigating the claim are followed. The NAVSEA Claims Panel (claims under one million) and NAVSEA Claims Board (claims over one million) review proposed claim settlements.

VIII. OPERATIONAL PHASE

8-A DELIVER TO FLEET ASSIGNMENT

Concurrent with the logistics management turnover cited above, the ship is delivered according to an Operational Assignment Modes for normal operational assignment.

8-B COASTAL FLEET

Coastal fleet - consists of those ships that are in full operation but not assigned to a deployed fleet (6th - Med; 7th - Wes Pac). Ships undergoing overhaul, repair or shakedown/refresher training prior to overseas deployment are normally assigned to the Coastal Fleet.

8-C COMBAT FLEET

The ships assigned to one of the deployed overseas fleets which are combat-ready.

8-D SCHEDULED MAINTENANCE

Regular overhauls are performed on a cycle approved by the CNO that provide for the periodic restoration of ships and equipments to specified standards.

8-E SHIP LIFE-EXTENSION PROGRAM OVERHAUL

This type of major overhaul is performed in order to extend ship life and therefore is much more extensive than regular overhauls.

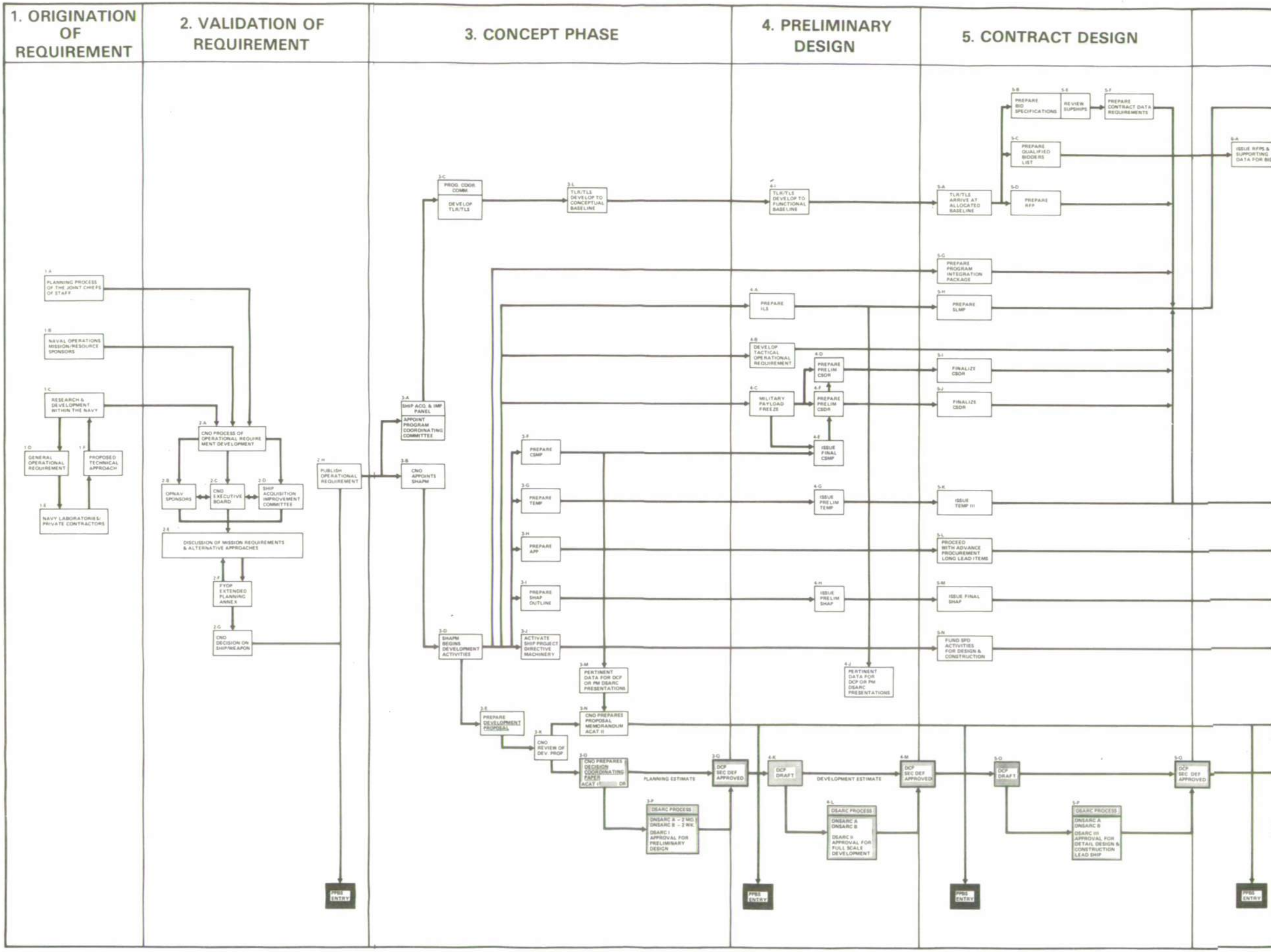
8-F DECOMMISSION

The process by which a ship is placed is an inactive status for transfer to the Reserve Fleet or ultimate disposal.

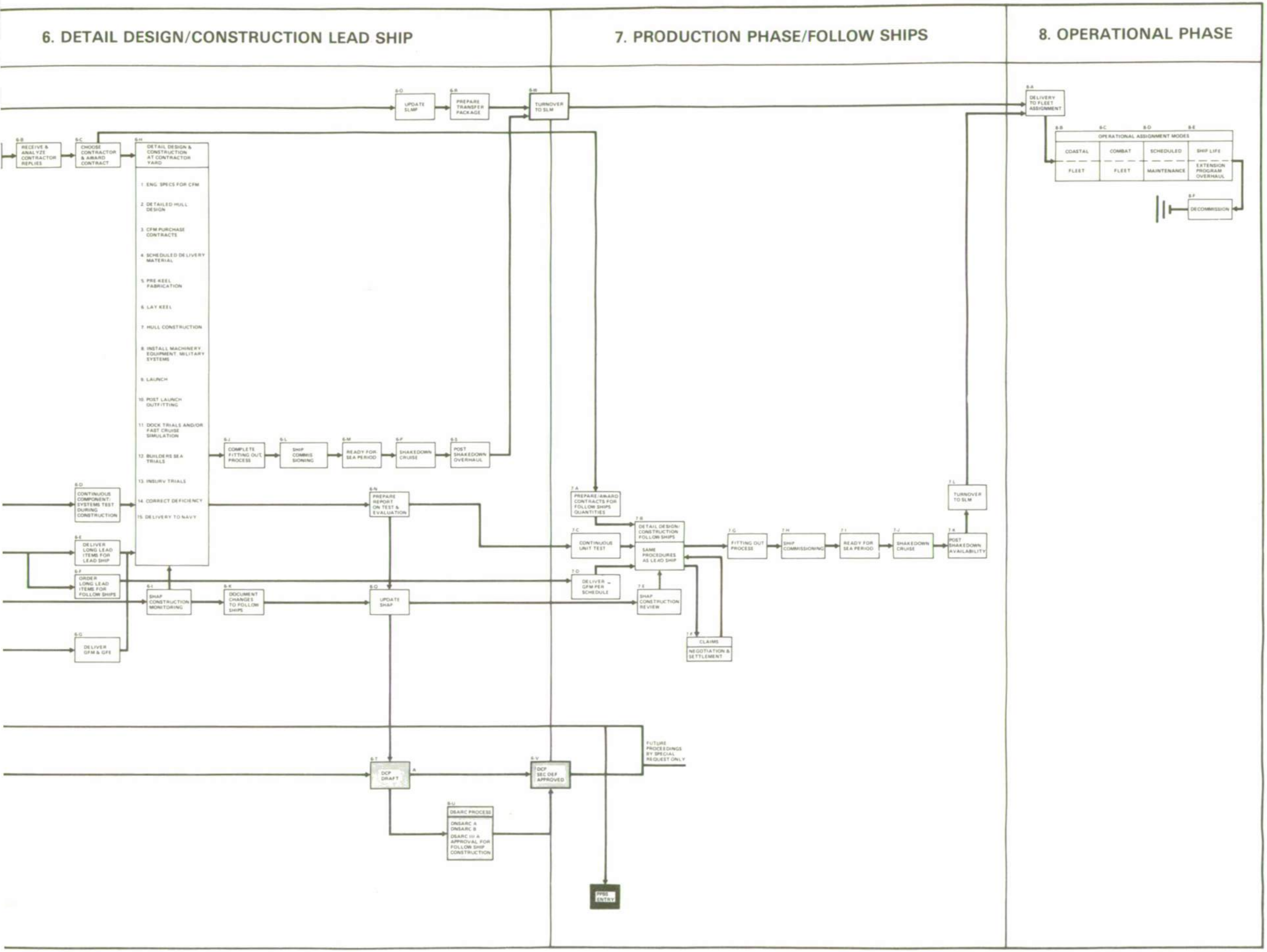
THE NAVY SHIP ACQUISITION PROCESS

DCP/DSARC PROCESS

PLANNED PPBS ENTRIES



1. ORIGINATION OF REQUIREMENT
2. VALIDATION OF REQUIREMENT
3. CONCEPT PHASE
4. PRELIMINARY DESIGN
5. CONTRACT DESIGN
1-A PLANNING PROCESS OF THE JOINT CHIEFS OF STAFF
1-B NAVAL OPERATIONS MISSION/RESOURCE SPONSORS
1-C RESEARCH & DEVELOPMENT WITHIN THE NAVY
1-D GENERAL OPERATIONAL REQUIREMENT
1-E NAVY LABORATORIES/PRIVATE CONTRACTORS
1-F PROPOSED TECHNICAL APPROACH
2-A CNO PROCESS OF OPERATIONAL REQUIREMENT DEVELOPMENT
2-B OPNAV SPONSORS
2-C CNO EXECUTIVE BOARD
2-D SHIP ACQUISITION IMPROVEMENT COMMITTEE
2-E DISCUSSION OF MISSION REQUIREMENTS & ALTERNATIVE APPROACHES
2-F FYDP EXTENDED PLANNING ANNEX
2-G CNO DECISION ON SHIP/WEAPON
2-H PUBLISH OPERATIONAL REQUIREMENT
PPBS ENTRY
3-A SHIP ACQ. & IMP PANEL
APPOINT PROGRAM COORDINATING COMMITTEE
3-B CNO APPOINTS SHAPM
3-C PROG. COOR. COMM
DEVELOP TLR/TLS
3-L TLR/TLS DEVELOP TO CONCEPTUAL BASELINE
3-D SHAPM BEGINS DEVELOPMENT ACTIVITIES
3-E PREPARE DEVELOPMENT PROPOSAL
3-F PREPARE CSMP
3-G PREPARE TEMP
3-H PREPARE APP
3-I PREPARE SHAP OUTLINE
3-J ACTIVATE SHIP PROJECT DIRECTIVE MACHINERY
3-K CNO REVIEW OF DEV. PROP
3-M PERTINENT DATA FOR DCP OR PM DSARC PRESENTATIONS
3-N CNO PREPARES PROPOSAL MEMORANDUM ACAT II
3-O CNO PREPARES DECISION COORDINATING PAPER ACAT I OR
PLANNING ESTIMATE
3-P DSARC PROCESS
DNSARC A – 2 MO.
DNSARC B – 2 WK.
DSARC I APPROVAL FOR PRELIMINARY DESIGN
3-Q DCP SEC DEF APPROVED
4-A PREPARE ILS
4-B DEVELOP TACTICAL OPERATIONAL REQUIREMENT
4-C MILITARY PAYLOAD FREEZE
4-D PREPARE PRELIM CSDR
4-E ISSUE FINAL CSMP
4-F PREPARE PRELIM CSDR
4-G ISSUE PRELIM TEMP
4-H ISSUE PRELIM SHAP
4-I TLR/TLS DEVELOP TO FUNCTIONAL BASELINE
4-J PERTINENT DATA FOR DCP OR PM DSARC PRESENTATIONS
4-K DCP DRAFT
DEVELOPMENT ESTIMATE
4-L DSARC PROCESS
DNSARC A
DNSARC B
DSARC II APPROVAL FOR FULL SCALE DEVELOPMENT
4-M DCP SEC DEF APPROVED
5-A TLR/TLS ARRIVE AT ALLOCATED BASELINE
5-B PREPARE BID SPECIFICATIONS
5-E REVIEW SUPSHIPS
5-F PREPARE CONTRACT DATA REQUIREMENTS
5-C PREPARE QUALIFIED BIDDERS LIST
5-D PREPARE RFP
5-G PREPARE PROGRAM INTEGRATION PACKAGE
5-H PREPARE SLMP
5-I FINALIZE CBDR
5-J FINALIZE CSDR
5-K ISSUE TEMP III
5-L PROCEED WITH ADVANCE PROCUREMENT LONG LEAD ITEMS
5-M ISSUE FINAL SHAP
5-N FUND SPD ACTIVITIES FOR DESIGN & CONSTRUCTION
5-O DCP DRAFT
5-P DSARC PROCESS
DNSARC A
DNSARC B
DSARC III APPROVAL FOR DETAIL DESIGN & CONSTRUCTION LEAD SHIP
5-Q DCP SEC DEF APPROVED
6-A ISSUE RFPS & SUPPORTING DATA FOR BID



6. DETAIL DESIGN/CONSTRUCTION LEAD SHIP
7. PRODUCTION PHASE/FOLLOW SHIPS
8. OPERATIONAL PHASE
6-B RECEIVE & ANALYZE CONTRACTOR REPLIES
6-C CHOOSE CONTRACTOR & AWARD CONTRACT
6-H DETAIL DESIGN & CONSTRUCTION AT CONTRACTOR YARD
1. ENG. SPECS FOR CFM
2. DETAILED HULL DESIGN
3. CFM PURCHASE CONTRACTS
4. SCHEDULED DELIVERY MATERIAL
5. PRE-KEEL FABRICATION
6. LAY KEEL
7. HULL CONSTRUCTION
8. INSTALL MACHINERY EQUIPMENT, MILITARY SYSTEMS
9. LAUNCH
10. POST LAUNCH OUTFITTING
11. DOCK TRIALS AND/OR FAST CRUISE SIMULATION
12. BUILDERS SEA TRIALS
13. INSURV TRIALS
14. CORRECT DEFICIENCY
15. DELIVERY TO NAVY
6-D CONTINUOUS COMPONENT/ SYSTEMS TEST DURING CONSTRUCTION
6-E DELIVER LONG LEAD ITEMS FOR LEAD SHIP
6-F ORDER LONG LEAD ITEMS FOR FOLLOW SHIPS
6-G DELIVER GFM & GFE
6-I SHAP CONSTRUCTION MONITORING
6-K DOCUMENT CHANGES TO FOLLOW SHIPS
6-J COMPLETE FITTING OUT PROCESS
6-L SHIP COMMISSIONING
6-M READY FOR SEA PERIOD
6-P SHAKEDOWN CRUISE
6-S POST SHAKEDOWN OVERHAUL
6-O UPDATE SLMP
6-R PREPARE TRANSFER PACKAGE
6-W TURNOVER TO SLM
6-N PREPARE REPORT ON TEST & EVALUATION
6-Q UPDATE SHAP
6-T DCP DRAFT
A
6-U DSARC PROCESS
DNSARC A
DNSARC B
DSARC III A APPROVAL FOR FOLLOW SHIP CONSTRUCTION
6-V DCP SEC DEF APPROVED
PPBS ENTRY
FUTURE PROCEEDINGS BY SPECIAL REQUEST ONLY
7-A PREPARE/AWARD CONTRACTS FOR FOLLOW SHIPS QUANTITIES
7-B DETAIL DESIGN/ CONSTRUCTION FOLLOW SHIPS
SAME PROCEDURES AS LEAD SHIP
7-C CONTINUOUS UNIT TEST
7-D DELIVER GFM PER SCHEDULE
7-E SHAP CONSTRUCTION REVIEW
7-F CLAIMS
NEGOTIATION & SETTLEMENT
7-G FITTING OUT PROCESS
7-H SHIP COMMISSIONING
7-I READY FOR SEA PERIOD
7-J SHAKEDOWN CRUISE
7-K POST SHAKEDOWN AVAILABILITY
7-L TURNOVER TO SLM
8-A DELIVERY TO FLEET ASSIGNMENT
8-B 8-C 8-D 8-E
OPERATIONAL ASSIGNMENT MODES
COASTAL
FLEET
COMBAT
FLEET
SCHEDULED
MAINTENANCE
SHIP LIFE
EXTENSION PROGRAM OVERHAUL
8-F DECOMMISSION

APPENDIX D

THE COST

ESTIMATING PROCESS

Appendix 4 of 5

Supports the final report entitled, A Study Of Ship Acquisition Cost Estimating In The Naval Sea Systems Command

Contract No. N00024-77-C-2013

INTERNATIONAL MARITIME ASSOCIATES, INC.

WASHINGTON, D.C.

OCTOBER 1977

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I COST ESTIMATING IS CARRIED ON BY A NUMBER OF ORGANIZATIONS WITHIN THE NAVY

There are a number of organizations within the Navy which have cost estimating or estimate validation responsibilities. Many of these organizations have capabilities which could be used on cost estimating for shipbuilding if so tasked. Others are already involved.

1. HEADQUARTERS ORGANIZATIONS

The Office of the Chief of Naval Operations and elements of the Naval Material Command prepare shipbuilding estimates. These organizations are shown on Figure D.1.

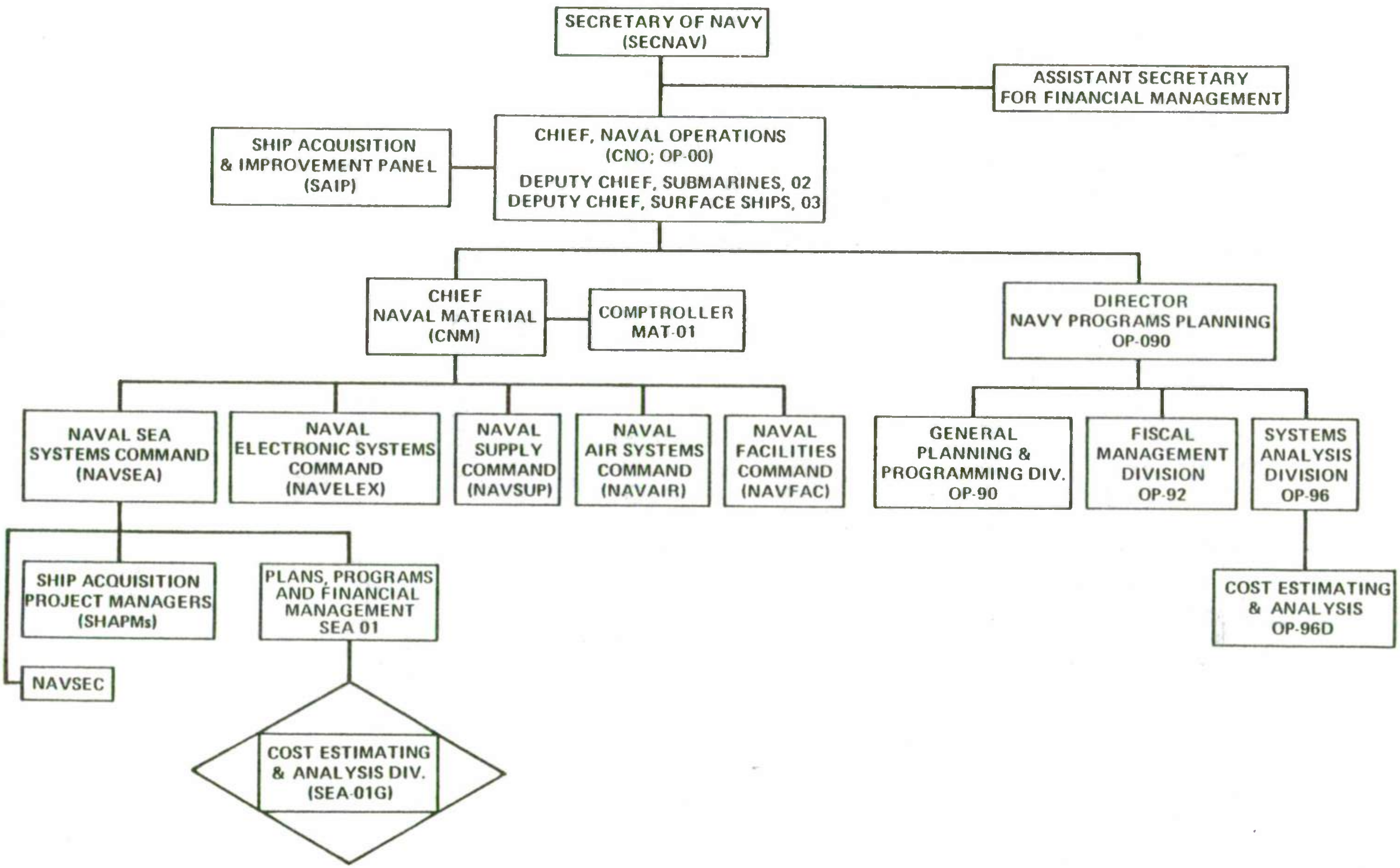
(1) Office of the Chief of Naval Operations

The General Planning and Programming Division (OP-90) validates operating costs and program factors for the FYDP, DNFYP, CPAM, POM, SAR, JFM and DCP compilation. This group also maintains the Navy Resources Model (NARM) and the Navy Cost Information System (NCIS).

The Fiscal Management Division (OP-92) is headed by the Navy Comptroller and it reconciles planning and programming cost estimates with annual budget back-up estimates, validates budget costing, provides budget and prior year cost data, reviews budget cost estimates that are inputs to economic analyses required to support budget programs.

FIGURE D.1

COST ESTIMATING ORGANIZATIONS IN THE NAVY



The System Analysis Division (OP 96) maintains a permament, dedicated cost estimating group capable of making periodic on-request studies of Navy programs, both ongoing and proposed, for the purpose of validating acquisition and ownership costs of major weapon systems, and providing the cost validation function in support of cost and effectiveness studies, CEB (CNO Executive Board) and PDRC (Procurement Development Review Committee) presentations. This group has access to all data within the Navy and employs parametric cost analysis with other techniques to keep CNO and the program sponsor informed of the results of independent analysis and validation.

(2) Naval Material Command

The Headquarters, Naval Material Command coordinates the cost analysis program within the Naval Material Command. This program:

- Provides through the SYSCOM estimating groups the capability for preparing independent cost estimates and evaluations of contractor proposals based on actual cost experience and statistical techniques.
- Includes documentation of estimate quality.
- Directs the execution of the Contract Cost Data Report (CCDR) program.

- Collects, processes, validates and stores data in support of the cost analysis program.
- Provides training programs for personnel assigned to cost estimating functions.

(3) Systems Commands

Project Managers (SHAPM) within the Naval Sea Systems Command (NAVSEA) have the organizational responsibility for cost estimates of the projects under their cognizance. SEA 01G, as the centralized cost estimating group, acts for the SHAPM's in preparing initial conceptual estimates, cost estimates for the Program Objectives Memorandum (POM), budget cost estimates, and contract estimates for new construction and ship conversions. SEA 01G is the focal point for various GFM cost estimates provided by NAVELEX, NAVAIR, and NAVSEC but its duties go far beyond being just that of an assembler. SEA 01G estimates the cost of the ship construction, the cost of installing all the various systems/equipments that are Government Furnished Material (GFM), and forecasts escalation and inflation percentages for use by the various Project Managers. NAVSEA 01G is for NAVSEA, the Cost Analysis/Estimating Group responsible for cost estimating policy and guidance. NAVSEA 01G13 is the focal point for all weapon system GFM furnished by NAVSEA 06. This includes guns, surface and ASW fire control systems, missile control systems, missile

launchers, surface and air search radars and submarines fire control systems. NAVSEA 01G13 validates the GFM estimates and adjusts them for inflation.

Within NAVSEA, other groups are also involved in the cost estimating process. NAVSEA 0444 provides NAVSEA 01G the estimates for "F" cog and "S" cog type electronic material listed on the Electronic Equipment List originated in NAVSEC. Examples of "F" cog would be Naval Tactical Data Systems (NTDS), gyro systems, and ship control instrumentation. Examples of "S" cog would be pumps and propulsion machinery. NAVSEA 06H provides SEA 01G the cost estimates for all Sonar equipment for surface ships and submarines. It is the function of NAVSEA 01G13 to validate and adjust for inflation the above cost estimates.

The Naval Ship Engineering Center (NAVSEC 6179), a field unit of NAVSEA, develops the actual requirements for electronic equipment. These requirements are listed on Electronic Equipment Lists which are sent to NAVSEA 01G for the POM and for ship/ship types as requested. SEA 012 will then distribute the lists as appropriate to various NAVSEA, NAVELEX, and in some cases to NAVAIR codes. The lists are returned to SEA 01G with appropriate cost estimates. SEA 01G has the responsibility of validating and applying

these to the ship total cost estimate.

Within the Naval Electronic Systems Command (NAVELEX), NAVELEX 504B is the Central Cost Estimating and Analysis Group for all cost estimates which NAVELEX furnishes SEA 01G. These cost estimates may originate in the Material Acquisistion Directorate, ELEX 501A or PME 107 for follow-on procurements of production systems/equipments or from the cognizant engineer for initial production of equipment/systems. These cost estimates can also be furnished by ELEX 504B when requested to do so. The NAVELEX furnished electronic components are called "Z" cog items.

Within the Naval Air Systems Command (NAVAIR), the Cost Analysis/Cost Estimating Group (NAVAIR 506) acts as the focal point for Command cost estimates and provides cost estimating policy and guidance. However, cost estimates for POM and other NAVAIR equipment and systems are provided SEA 01G by NAVAIR 537, the Ship Installation Division. The cost estimating function of NAVAIR 537 is a secondary one as its primary is for procurement and installation of shipboard equipment to support aircraft. NAVAIR 506 provides aircraft, aircraft equipment, and missile cost estimates.

2. FIELD ORGANIZATIONS

Several field activities under the command of NAVSEA have large numbers of personnel regularly engaged in estimating shipwork (overhauls) costs. It should be noted that they are not associated with new construction budget cost estimates.

(1) Naval Shipyards

The Commander Naval Sea Systems Command exercises command and management control of the eight naval shipyards.

Portsmouth	Philadelphia
Norfolk	Charleston
Long Beach	Mare Island
Puget Sound	Pearl Harbor

These facilities employ approximately 63,000 people. The principal function of the naval shipyard is to repair and overhaul ships. They have not engaged in new construction since 1968.

Each naval shipyards' cost estimating ability in the Planning and Estimating Division as of June 30, 1976 is shown on Table D.1.

The planning and estimating function in the naval shipyard is very similar to the corresponding function found in private ship repair yards. The work involves preparation of job orders which

TABLE D.1

PLANNING AND ESTIMATING MANPOWER
IN NAVAL SHIPYARDS
(as of June 30, 1976)

Shipyard	Supervisory & Clerical	Planners & Estimators
Portsmouth	42	112
Philadelphia	51	97
Norfolk	29	191
Charleston	31	122
Long Beach	21	140
Mare Island	72	217
Puget Sound	51	204
Pearl Harbor	24	138
	321	1221

include breaking the jobs down into key operations by shop and estimating the manhours and material required for each key operation. They estimate from previous experience, returned costs, plans, specifications, sketches and instruction books.

The planners and estimators are primarily drawn from production forces promoted from the inside shops and waterfront. The average civil service grade scale for planners and estimators is equivalent to

GS-11, i.e., $17,000 - $22,000 pay range.

The personnel in these offices deal with expenditures and estimates that are much larger and more complex than is the case in a typical private ship repair firm. Therefore, with this capability, it would not be a quantum jump to do whole ship or new ship construction estimations.

It is not the purpose of this report to suggest that naval shipyards do new ship estimates for the Navy, but it does identify a reservoir of estimating talent that may be drawn upon in the event expansion of SEA 01G is decided.

Located at certain naval shipyards are organizations titled "Planning and Estimating for Repairs and Alterations" (PERA). Each shipyard PERA has responsibilities for particular ship types. During the course of this study, two PERAs -- one for amphibious and small craft and the other for cruisers and destroyers -- were examined for their ability to estimate the cost of installing, checking out and integrating major sub-systems in ships. It was found that their procedures are orderly, definitive and detailed. Further, they are validated by Ship's Departure Reports and are updated for factors which materialize in unique and novel circumstances.

The PERA program for ship overhauls was initiated in 1966 as a plan of action to improve the advance planning, integration and control procedures required for the overhaul of ships. New urgency was lent to the program on December 30, 1975 by the NAVSEA Instruction 5400.25, with a statement of specific responsibilities and authority.

(2) Supervisor Of Shipbuilding,Conversion And Repair, USN (SupShips)

The principal mission of the SupShips organization is to administer the Navy and other DOD shipbuilding, design, conversion, and facility contracts at private shipyards. The SupShips also award and administer contracts for ship overhaul, repair, alteration, and activation. This work is done under master contracts for repair and alteration of naval ships.

The SupShips organization now has 15 offices in the major shipbuilding and repair ports of the United States. The total staff includes 221 officers and 3,063 civilian employees (June 30, 1976). The staffing by organizational component is shown on Table D.2.

TABLE D.2

STAFFING OF THE FIFTEEN OFFICES
OF THE
SUPERVISORS OF SHIPBUILDING, CONVERSION & REPAIR

Organizational Units in each SUPSHIP Office	Officers	Civilians
Command Staff	63	84
Contract Department	12	245
Business Review and Cost Monitoring	3	83
Quality Assurance	27	615
Industrial Production	46	193
Engineering	22	447
Planning and Estimating*	12	504
Naval Architecture	0	61
Allowance Lists	2	153
Administrative Services	24	562
Other	16	116
Total - 15 Offices	221	3036

* For Newport News, this group is called the Proposal and Evaluation Division.

The SupShips office at Newport News Shipbuilding and Dry Dock has what is known as the Proposal and Evaluation Division. This division develops budget estimates for repairs and alterations and evaluates proposals received from the shipyard for doing this work. They also adjudicate changes under the various contracts, i.e., new construction, repair, and alteration.

As of January 1977, this group had a staff of 31 which was made up of five cost engineers and 26 technical analysts. The cost engineers are grades 12 and 13 and are college engineering graduates with an average of 22 years shipyard and associated experience. The 26 technical analysts are mostly from the Norfolk Naval Shipyard.

Since the other SupShip organizations have similar estimating talents, the Navy has yet another pool of over 500 people with estimating experience to draw from.

3. NAVAL SHIP CONSTRUCTION PROGRAMS ARE SO EXTENSIVE AND COMPLEX THAT OVER 50 OFFICES ARE INVOLVED FOR PROVIDING COST INPUTS

Figure D.2 illustrates the broad range of activities that have cost analysis and cost estimating responsibilities. For ship acquisition (which involves new ship construction, modernization and repair), seven different budgets are involved.

- SCN -- Ship Construction,Navy
- RDT&E -- Research Development, Test and Evaluation
- FMS -- Foreign Military Sales
- FMP -- Fleet Modernization Program
- O&MN -- Operations and Maintenance, Navy
- OPN -- Other Procurement, Navy
- WPN -- Weapons Procurement, Navy

The organizations that have greatest input to the areas of responsibility shown on Figure D.2 are framed in a dark border.

It can be observed generally that SEA 01G is the predominant organization with respect to new construction and conversion estimates and develops many of the support functions such as economic analysis and economic forecasting.

For Government Furnished Material, the predominate source of cost information is from NAVSEA 06 and 04 and other participating managers within the SYSCOMS. The field organizations such as the PERA SupShips

FIGURE D.2

SHIP COST ESTIMATING AND COST ANALYSIS RESPONSIBILITIES

	APPROPRIATIONS	NAVSEA HEADQUARTERS	OTHER SYSCOMS & SUPPORT	OTHER GROUPS
ACQUISITION				
SHIP				
New Construction & Conversion - Total Cost				
Conceptual	SCN RDT&E FMS	01G	SEC 6112D	OP96D CNA
Budget	SCN RDT&E FMS	01G		
DSARC	SCN RDT&E FMS	01G	ELEX, AIR	OP96D OSD - CAIG
Contract - Private Shipyards	SCN RDT&E FMS	01G		
- Naval Shipyards	SCN RDT&E FMS	01G	N.S.Y.	
Change Orders				
Budget	SCN FMS	01G		
Contract	SCN FMS	01G PM	SUPSHIP	
Alterations/Repairs (FMP)				
Budget	OMN FMS	SLD's	PERA'S	
Contract	OMN FMS		N.S.Y. SUPSHIP	
Contract Escalation				
Budget	SCN FMS	01G		
Contract	SCN FMS	01G	SUPSHIP DCAA	
GOV'T. FURNISHED MATERIAL				
Search Radars	The following	01G 652		
Gun Mounts		01G 6531 653G PMS 4043		
Gun Fire Control System	appropriations	01G 6532 653G PMS 4043		
Missile Launchers		01G 654 06G5 PMS 404 PMS 403		
Missile Fire Control Systems	are possibilities	01G 654 653G 06G5 PMS 403 PMS 404		
Underwater Fire Control Systems - Subs		01G 660D 660M		
Underwater Fire Control Systems - Surface	for all GFM:	01G 661D1 660M		
ASW Launchers & Torpedo Tubes - Surface		01G 661D2 660M		
Combat System Integration & Support	SCN, WPN,	01G 06C	SEC 6170	
Sonars		01G 06H 660 661		
Z Cog. Electronic Countermeasures	OPN, FMS,	01G	PME 107	
Z Cog. Communication & Navigation Radar Eq.		01G	ELEX 05 AIR 537	
F Cog. Material	RDT&E.	01G 044	SEC 6170	
S Cog. Material		01G 044	SEC 6140	
Catapults & Aircraft Support		01G	AIR 537	
Medical		01G	BUMED	
Nuclear Propulsion		08		
Gas Turbines		01G 04T PMS 399	SEC 6146	
SUPPORT FUNCTIONS				
Life Cycle Costs	ALL	01G 04V AM's	SEC 6112D	OP96D CNA
Technical Cost Analysis	AEL	01G PM AM's	NAVSEC SEIPSHIP DCAA	
Should Cost Studies	ALL	01G PM 02	DCAA PV'T. Contractor	
Economic Analysis	ALE	01G PM	N.S.Y. PV'T. Contractor	OP96D CNA
Economic Forecasting	SCN FMS ALL OTHER APPRO.	01G -		OP96D CNA OSD (COMPT) OSD (COMPT)
Cost Estimate Validation	ALL	01G		OP96D OSD - CAIG
Design To Cost	AEE	01G 0745	SEC6112D	OP96D CNA OSD - CAIG
Claims	SCN FMS	0282 PM	SUPSHIP DCAA PV'T. Contractor	Various Claim Settlement Teams
Contract Cost Analysis	ALE	02	ELEX 02 AIR 02 ETC.	MAT02
Central Cost Monitor	AEL	01G		OP96D

have a predominant role with respect to changes, fleet modernization programs, overhauls and claims.

NAVSEC 6112D is heavily involved in making ship construction and life cycle cost estimates during design development.

There are other estimating organizations that act as advisors to CNO or OSD, namely, OP 96D in OPNAV and the CAIG in OSD. The Center for Naval Analysis(CNA) provide cost analysis to CNO. Except for SEA 01G, sub-contractors and manufacturers are often a prime source of basic cost estimating.

II THE COST ESTIMATING ORGANIZATIONS PROVIDE ESTIMATES FOR THREE PRIMARY PURPOSES

These purposes are encountered at various stages in acquisition programs and set the need for a continuous process of estimating to facilitate decision-making. The problems of estimating for each purpose are similar, but the guidelines differ and the estimating results may be expected to have more validity as the process moves onward in the acquisition of a system. Inaccuracies in estimates prepared for these purposes cause certain problems.

1. COST ESTIMATING FOR PLANNING AND PROGRAMMING SO THAT THE RELATIVE BENEFITS OF DIFFERENT ITEMS CAN BE EVALUATED.

At the conceptual stage of acquisition, the government is usually faced with several choices. There is competition among conceivable and conceived configurations and among their components. Before reaching a decision on whether to provide funds for a proposed program, some estimate of the final cost of that program is necessary so that its expected benefits can be evaluated in terms of its costs.

Similarly, where a program has been underway but has not reached final commitment stage, the decision to proceed or to revise a requirement may depend on the estimated cost of completing the program.

Cost estimates for planning and programming purposes in connection

with new programs are required well in advance of the expenditure of funds and often before there is any firm definition of the Navy's requirement, or of the consequences of not meeting it. In such circumstances cost estimates cannot be expected to be precise. Also, during the planning stage many new ideas are presented, each of which must be evaluated for its probable effect on costs. Hence, there is a tendency to ask for a large number of cost estimates during the planning phase.

In the case of planning estimates, detailed cost analyses are not generally feasible, nor are they essential. Analogous or parametric estimating techniques are usually employed. The estimates are rough, but they are adequate for an activity such as requirement definition.

Unrealistic planning cost estimates cause problems in two ways.

- The validity of cost/benefit decisions based on those estimates may be highly questionable.
- Planning estimates are frequently misused for measuring cost growth by ignoring the conditions under which they were made and the changes in requirements which intervened. This has resulted in criticism of estimates which may not have been reasonable at the time they were made.

2. COST ESTIMATING FOR BUDGETING IS BASED UPON THE BEST ESTIMATE OF WHAT THE ITEMS WILL COST AT THE DATE THEY ARE TO BE PROCURED

After a decision has been made to go forward with a program, or to bring additional components into the Navy inventory, a budget must be prepared and submitted to the President and then to the Congress.

The budget preparation process precedes controcting by at least two years and often longer. In oddition to the estimating errors generoted by the time factor, the budget cost estimate is sometimes affected by vogue requirements. Alsa, estimates made under limited time pressures moy not reflect the quolity expected of an estimate for this purpose.

Budget estimates hove a direct impact upon the contracting award. Procurement personnel occasionolly find, upon opening of bids or quotations, that no bid or quote is within the funds budgeted. It then becomes necessary to obtain additional funds or to revise the requirement. To the extent that such situations arise because of inaccurote budget estimates, any improvement in their accuracy wauld improve the procurement process.

The techniques used for budget estimates range throughout the onolytical spectrum. Comptroller (SEA 01G) personnel have nominal responsibility for the technical quality of the estimates, but programming, engineering, and GFM specialists provide important input data.

3. COST ESTIMATING FOR CONTRACTING PROVIDES AN ESTIMATE FOR THE PROPER PRICE LEVEL OR VALUE OF THE PRODUCT OR SERVICE TO BE PURCHASED

The controcting process includes two octions by the government which involve cost estimating techniques.

- The Independent Government Cost Estimate, which is prepared before receipt of quotation.

- The Government Contract Negotiation Objective which is prepared after receipt and analysis of company proposals.

The Armed Services Regulation (ASPE) 3082.1 provides that,

> "Before soliciting quotations, every contracting officer should develop where feasible, an estimate of the proper price level or value of the product or service to be purchased."

The contracting officer is encouraged to review technical and prior procurement data and to consult with other specialists as necessary. The ASPR estimate has come to be known as the Independent Government Cost Estimate (IGCE).

The principal effect of unsatisfactory estimates on contracting is to create more work in administration areas because such estimates are either based on the availability of funds or are used for fund allocation -- in either event, financial reprogramming will be needed.

In competitive procurement, the normal practice of accepting the low bid will justify the reasonableness of the price in most circumstances. If the government has prepared a cost estimate of reasonable quality, a bid

which is unreasonably low compared with the estimate may indicate that the offerer is not fully cognizant of the contractual requirement. Such a low bid may also indicate the possibility of a buy-in.

Despite the multiplicity of cost estimating organizations within the Navy, their primary objectives revolve around these three purposes just discussed.

III THE PRIMARY COST ESTIMATING GROUP FOR SHIPBUILDING PROGRAMS IS THE NAVSEA COST ESTIMATING AND ANALYSIS DIVISION (SEA 01G)

The Cost Estimating and Analysis Division, SEA 01G, is the principal cost estimating organization for shipbuilding programs. This chapter describes the organizational relationships, organization, functions and techniques of the Division.

1. GENERAL PURPOSE AND ORGANIZATION OF THE DIVISION

As shown on Figure D.1, SEA 01G is part of the Directorate for Plans, Programs, and Financial Management, SEA 01, in the Naval Sea Systems Command. It is the focal point for preparing cost estimates for ship construction at the request of other directorates and divisions. It is SEA 01G's primary task, as discussed in Chapter I, to estimate the basic ship cost and include GFM costs and other factors to establish a final end cost estimate. This estimate, after review and concurrence of the Ship Acquisition Project Manager (SHAPM) involved, is entered into various management systems requiring such estimates.

Planning and budgeting estimates are prepared by established dates in the applicable annual cycles, and must be documented and classified as to quality which relates to the completeness and adjudged reliability of

available inputs. Other estimates must be submitted within requested periods, which can be exceptionally short, occasionally on the same day. Examples of the other services performed are: trade-off analyses for ship characteristics or GFM, habitability features on ships, cost effectiveness, life cycle costs policy and guidance, analysis and projection of economic data such as labor trends, material inflation, etc.

What is now the Cost Estimating and Analysis Division was previously referred to as Ship Cost Estimates and Analyses Office, Ship Acquisition Directorate, Code 05F2. Beginning in 1966, the organization underwent several title changes until it finally acquired its present title. Through July, 1969 it was not officially divided into any organizational subdivisions, probably due to its limited size. Before September, 1970, however, it was divided into the Ship Cost Estimating Branch and Cost Analysis Branch with both reporting to a Director. This has been the Division's organizational structure since.

The Ship Cost Estimating Branch is comprised of three sections, Combatant Ship Cost Estimating, Auxiliary Ship Cost Estimating and Combat Systems Cost Estimating. The Cost Analysis Branch is also separated into three sections: Systems Analysis; Policy/Procedures and Review; and Cost Data Analysis. The functional assignments in this organization

are shown in Figure D.3.

2. THE SHIP COST ESTIMATING BRANCH (SEA 01G1) IS THE FOCAL POINT FOR SHIP COST ESTIMATES

The Ship Cost Estimating Branch has responsibility for developing unit costs for ships and for expanding these costs into end costs for ship programs.

(1) A Large Variety of Ship Categories and Types Require End Cost Estimates

Table D.3 gives an idea of the variety and numbers of ships and craft which require attention on different occasions in terms of estimating the cost of construction or conversion.

Sections 01G 11 and 12 maintain data banks, past bids, etc. in sufficient detail to permit expeditious estimating with either analogous or parametric techniques on any of the ship types shown. They also estimate the labor cost of installing and integrating weapons and electronics systems on ships.

In the early stages of ship program development, many tentative estimates are prepared before a more or less final configuration is settled on and Figure D.4 illustrates this fact.

FIGURE D.3

ORGANIZATION CHART FOR COST ESTIMATING AND ANALYSIS DIVISION NAVSEA - 01G

BRIEF DESCRIPTION OF PRINCIPAL FUNCTIONS
AS OF DECEMBER 1976

PREPARED BY IMA – 12/22/76

**DIRECTOR
COST ESTIMATING & ANALYSIS DIVISION
NAVSEA-01G**

ESTIMATING BRANCH HEAD, 01G 1 (VACANT SINCE 1972)

- **COMBAT SHIP ESTIMATING SECTION, 01G 11, HEAD & 4 ESTIMATORS**
  COST ESTIMATES DURING ALL PROCUREMENT STAGES FOR: NEW OR R&D COMBATANT SHIPS; CONVERSIONS, ALTERNATIVE PROVISIONS; NAVAL SHIPYARD PLANNING OF MANPOWER. DOCUMENTATION & CLASSIFICATION OF ESTIMATES.
- **AUXILIARY SHIP ESTIMATING SECTION, 01G 12, HEAD & 3 ESTIMATORS**
  FUNCTIONS ARE SAME AS LISTED FOR 01G 11: BUT AUXILIARY SHIPS, SMALL CRAFT, AIRCRAFT CARRIERS, PHMS.
- **COMBAT SYSTEMS COST ESTIMATING SECTION, 01G 13, HEAD & 3 ESTIMATORS**
  COLLECT, VALIDATE, DEVELOP ESTIMATES OF COST FOR WEAPONS, ELECTRONICS, & ASSOCIATED SOFTWARE. (PRINCIPALLY GFM). ESTIMATE COST OF ALTERNATIVES. ESTIMATE COST OF COMMERCIAL TYPE ELECTRONICS. MAINTAIN INDICES FOR COST PROJECTIONS.

ANALYSIS BRANCH HEAD, 01G 2

- **COST DATA ANALYSIS SECTION, 01G 22, HEAD & 5 ANALYSTS**
  COLLECT & PROJECT ECONOMIC DATA FOR SHIPBUILDING TO ISSUE GUIDANCE FOR ESTIMATES OF INFLATION, ESCALATION; LABOR, OVERHEAD & PROFIT RATES; PRODUCTIVITY, LEARNING CURVES, ETC.
- **SYSTEMS ANALYSIS SECTION, 01G 21, HEAD & 0 ANALYSTS**
  INTEGRATE COST DATA FOR ECONOMIC & LIFE CYCLE ANALYSIS. DESIGN AND MANAGE COMPUTER PROGRAMS FOR COST ANALYSIS & COST ESTIMATING. MAINTAIN COST DATA BANKS WITH ADP.
- **POLICY, PROCEDURES, & REVIEW SECTION, 01G 23, ACTING HEAD (HEAD OF 01G 21) & 1 ANALYST**
  COORDINATE REVIEW & ANALYSIS OF COSTING OPERATIONS. ASSURE COMPLIANCE WITH REQUIREMENTS. AUDIT SHIPYARD MANHOURS & SURVEY CAPABILITY. PARTICIPATE IN "SHOULD COST" & TECHNICAL ANALYSIS REVIEWS.

TABLE D.3

CATEGORIES AND TYPES OF NAVAL SHIPS ESTIMATED

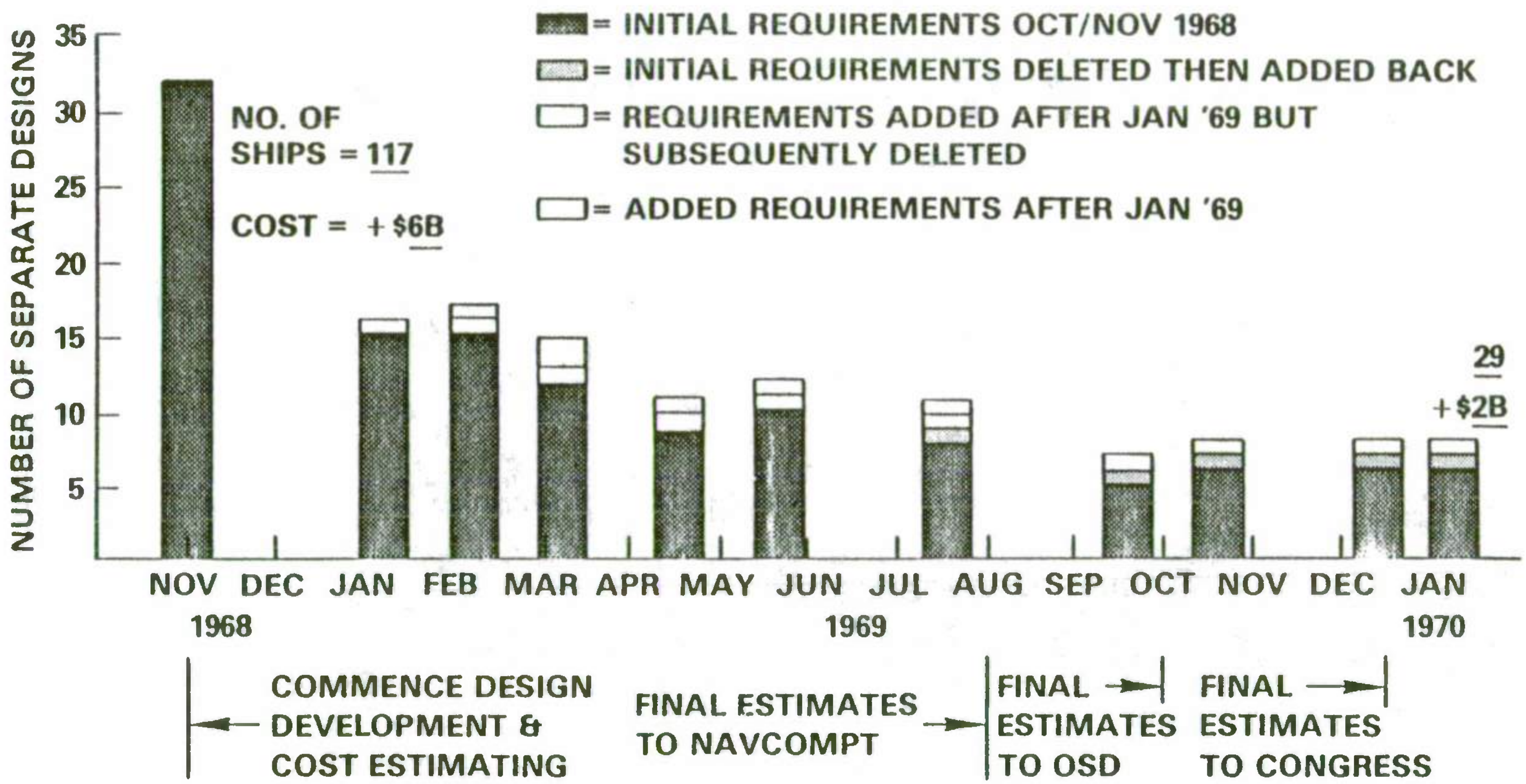
Combatant Ships		Types
Aircraft Carriers		5
Surface Combatants		9
Patrol		3
Command Ships		1
Submarines		4
Amphibious Warfare Ships		11
Mine Warfare Ships		3
	Sub-Total	36
Combatant Craft		
Patrol Craft		7
Landing Craft		7
Mine Countermeasures Craft		5
Riverine Warfare Craft		5
SEAL Support Craft		4
Mobile Inshore Underseas Warfare Craft		1
	Sub-Total	29
Auxiliary Ships		43
Service Craft		55
	Total	163

SOURCE: Classification of U.S. Naval Ships and Craft, January 6, 1975.

FIGURE D.4

NUMBER OF SEPARATE DESIGNS ESTIMATED FOR FY '71 SCN PROGRAM

(EXCLUDES SERVICE & LANDING CRAFT AND CONCURRENT OUT YEAR REQUIREMENTS)



(2) A Variety Of Government Furnished Material (GFM) Also Enters Into The Estimating Process

The cost estimates for Government Furnished Material (GFM) are made initially by all of the Systems Commands and forwarded to SEA 01G. Table D.4 identifies some of the GFM and principal suppliers. In the context of ship project management and cost estimating they are designated as Participating Managers (PARMs). While the range of individual items they are responsible for is very extensive, Table D.5 summarizes the total numbers of certain weapons and electronics systems that must be considered for shipboard installation. Table D.6 and Figure D.5 are examples of the kind of data the PARMs provide to the Cost Estimating and Analysis Division (SEA 01G).

An appreciation for the interrelationships among the NAVSEA organizations responsible for GFM cost estimates to the SHAPM and SEA 01G can be gained by tracing the process using the support provided by the Deputy Commander for Weapons, Systems and Engineering (SEA 06) as an example. The flow of information is shown on Figure D.6.

In SEA 06, providing cost estimates is a direct responsibility of the hardware Project Manager (PM) who looks at the cost estimate function as a collateral duty as he must allot the major share of his

TABLE D.4

SOURCES FOR GFM ESTIMATE REQUESTS

COMMAND	GFM INPUTS FOR SHIPS
NAVAIR	Catapults, Arresting Gear, Landing Aids, Shop Equipment
NAVELEX	Communication Equipment, Electronic Countermeasures
NAVSEA 06	Radars, including Fire Control Sonars Launchers Guns
NAVSEA 04	Naval Tactical Data System AN/UYK 7 Computers Turbines, Gears, Generators, etc. Gas Turbines Pollution Equipment
NAVSEA 08	Nuclear Propulsion Equipment
BUMED	Medical Equipment
SPECIAL PROJECTS	Strategic Ordnance

TABLE D.5

MAJOR WEAPONS AND ELECTRONICS SYSTEMS ESTIMATED

Gun mounts	15
Gun fire control systems	6
Launchers for missiles or aircraft	11
Guided missile fire control system	9
Underwater fire control system	6
Search and countermeasure Radars	35
Surface ship Sonars	22
Surface ship depth sounders	2
Submarine Sonars	47
Submarine depth sounders	14
Central processing units for computer systems	7
Electronic counter-measure systems	50
Total	224

TABLE D.6

A PARTIAL LIST TYPICAL OF DATA FURNISHED TO NAVSEA 01G

SCAT CODE	CHAR ID	CHAR NO	SUBCATEGORY DESCRIPTION	EQUIPMENT MODEL	QUAN NEW/ROB	PROCURE COG.	COST ESTIMATE ($)
	41	1	Function Remote Unit	KWX-8/TSEC	3	CNO	
	42	1					
	99	1					
	41	1	Converter	CV-2757/SGC	2 @$3000	NAVELEX	6,000
	42	1					
1436	41	1	Transmitter-Teletype Cntrl	C-1004B/SG	4	ESO	
	42	1					
	45	1					
	99	1					
1418	42	1	Camparator Convertor	AN/URA-( ) 4	3@$4000	NAVELEX	12,000
	45	1					
	410	1					
	42	1	Teletypewriter	AN/UGR-9	6	ESO	
	43	3					
	410	1					
	99	1					
1517	43	1	Multichannel Telegraph Ter	AN/UCC-1-D(V)R-4	1@$23,000	NAVELEX	23,000

TABLE D.6
(continued)

A PARTIAL LIST TYPICAL OF DATA FURNISHED TO NAVSEA 01G

SCAT CODE	CHAR ID/NO		SUBCATEGORY DESCRIPTION	EQUIPMENT MODEL	QUAN NEW/ROB	PROCURE COG.	COST ESTIMATE
1424	43	1	Gen. Address Reading Device	AN/UYK-20	1@$50,000	NAVELEX	50,000
	43	4	Security Equipment	TSEC/KG-14 (MOD 5)	4	CNO	
	43	2	Security Equipment	TSEC/KWR-37A (MOD 8)	2	CNO	
	43	1	Teletypewriter	AN/UGC-77	1	ESO	
	43	2	Reperforator	TT-605/UG	2	ESO	
	44	1	Security Equipment	TSEC/KL-47	1	CNO	
	44	1	Security Equipment	TSEC/HL-18	1	CNO	
	23	2	Power Supply	HYP-2/TSEC	2	CNO	
	45	2	Indicator Light	ID-866/SG	2	ESO	
	46	2	Security Equipment	TSEC/KY-8	2	CNO	
	46	8	Switching Unit	SA-1712/UR	8@$300	NAVELEX	2,400
	46	2	Switching Unit	SA-1711/UR	2@$150	NAVELEX	300
	46	4	Secure Audio Patch	C-7594A/U	4@$3200	NAVELEX	12,800
	99	2					
	46	2	Interconnection Box	J-2910/UR	2@$250	NAVELEX	500
	31	5	Elex Eq. Cabinet	CY-45168/U	5	ESO	
	48	1	Relay Device	C-4621/SR	1	ESO	
	49	2	Security Equipment	TSEC/KG-40	4	CNO	
	410	1	Switch	SA-734/SG	1	ESO	
	411	4	Security Equipment	TSEC/KY-75	4	CNO	

COST ESTIMATE DOCUMENTATION SUMMARY

FIGURE D.5

NAVSEA 7300/4 (4-75)

FY-DOLLARS	SHIP CLASS	SOURCE (SEA CODE)	PREPARED BY (Signature)	DATE

ESTIMATE CATEGORY	APPROPRIATION	BUY (of units)

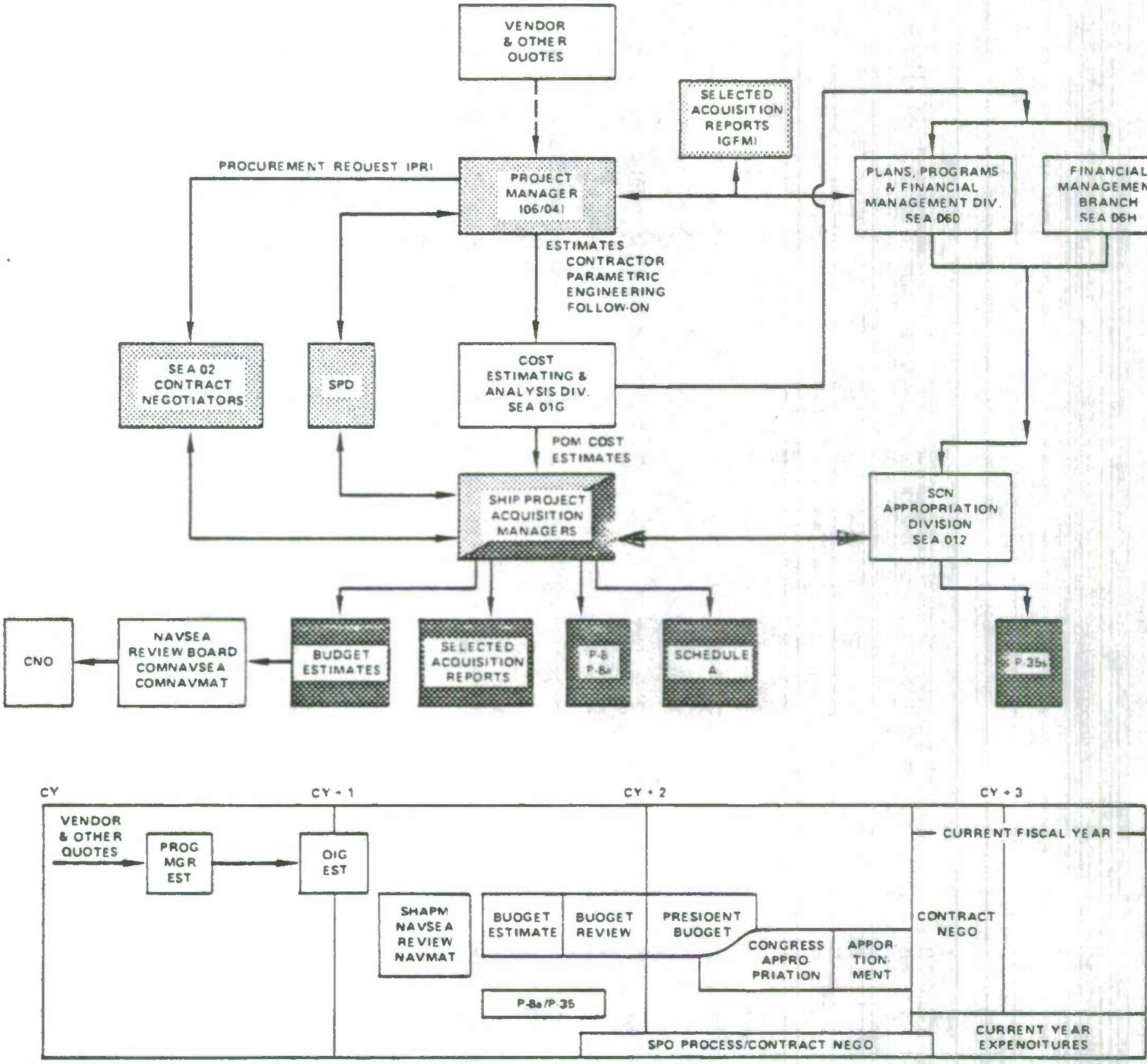
EQUIPMENT

I. COST DATA (In $ 000)
UNITS PER SHIP:

	ITEM	LEAD SYSTEM COSTS	FOLLOW SYSTEM COSTS
A.	EQUIPMENT COSTS		
1.	HARDWARE		
a			
b			
c			
d			
e			
f			
g			
h			
i			
2.	GFE		
a			
b			
c			
d			
e			
f			
g			
3.	DEVELOPMENT COSTS		
4.	PRODUCTION START-UP		
5.	ORDALTS		
6.	SOFTWARE/ PROGRAMMING		

	ITEM	LEAD SYSTEM COSTS	FOLLOW SYSTEM COSTS
7.	SHIPPING FIXTURES		
8.	PROJECT MANAGEMENT		
9.	I & C SPARES		
10.	DESIGN ENGR. CHANGES		
11.	TRAINING		
12.	SYS. TEST & EVAL.		
13.	TEST EQUIP.		
14.	INITIAL SPARES/ SUPPLY SUPPORT		
15.	CONTR. FIELD ENGR. SERVICES		
16.	GOVT. FIELD ENGR. SERVICES		
17.	TECH. DATA, DOC., OD's, OP's		
18.	ILS MGT		
19.	QA + RMA		
20.	OTHER COSTS		
a			
b			
	TOTALS		
B.	SYSTEMS ENGINEERING COSTS		
C.	SQT COSTS		

FIGURE D.6
NAVAL SEA SYSTEMS COMMAND GFM COST ESTIMATING PROCESS



HARDWARE, INITIAL SPARES & OTHER SHAPM COSTS

HARDWARE PLUS INITIAL SPARES

duties to design, procurement, and the many other aspects of his job required to deliver systems/equipments as scheduled. SEA 01G can and does prepare cost estimates, on an exception basis, for ordnance equipments but the usual case is that they accept, review, and validate the SEA 06, PM's, and SEA 04's estimates for the hardware and initial spares.

It is important to note the difference in cost philosophy between the hardware Project Managers, SEA 06, SEA 04, and SEA 01G. The PM's, SEA 04, and SEA 06's function is to provide realistic cost estimates and then hold the procurement prices and schedules in line as detailed in the hardware contract. The SEA 01G group must insure that the Ship Acquisition Project Manager will allot enough money to cover the hardware contract cost estimate and to cover all contingencies including those costs chargeable to the SHAPM by the shipbuilder for installation, integration, test firings, Weapon Systems Accuracy Tests (WSAT), Consolidated Operability Tests (COT), etc. SEA 01G also adds or corrects inflation factors as necessary. A percentage factor is usually added for engineering change proposals. The SEA 01G cost estimate will, therefore, always be appreciably higher than that of the PM.

Copies of the SEA 01G revised estimates are forwarded to the Plans, Programs and Financial Management Division, SEA 060 for information and also to SEA 012 where the SEA 01G estimates becomes the basis for SEA 012 Budget Exhibit P-35 which is subsequently forwarded to the SHAPM. For Sonar, estimates are forwarded to SEA 012 by SEA 06H and becomes the basis for the Sonar P-35's. As shown in Figure D.6, the SEA 01G GFM cost estimate is also forwarded to the appropriate SHAPM as part of the total ship end cost in the current Fiscal Year Budget Estimate where it is used as the basis for the Budget Exhibits P8 and P8a, Schedule A, and Selected Acquisition Reports (SAR) for major equipments. It is the cost estimate that is used by the SHAPM to prepare the Budget Estimate for review by the NAVSEA Review Board, approval by the Commander, Naval Sea Systems Command and then forwarded to the Chief of Naval Material and the Chief of Naval Operations. The above oversimplified process as diagrammed at the bottom of Figure D.6 is completed in approximately 12 to 15 months.

After the ship is budgeted, referring to Figure D. 6, the SHAPM and the Participating Managers (PARMS) will negotiate for the necessary GFM and support via the Ship Project Directives (SPD) system and, at the appropriate time in accordance with the directives set

forth in the SPD, the Project Manager, PARM (SEA 04, SEA 06) will issue a Procurement Request (PR) to the Contract Division (SEA 02). A Request for Proposal follows and after receiving bids, NAV SEA 02 will, after consultations with the Project Manager and SHAPM, award the contract and monies will then be directed by the SHAPM.

The Project Manager, SEA 04 or SEA 06 will then be responsible for the performance of the contract as required by the SPD and must notify the SHAPM of proposed technical baseline changes; if the contract levels exceed the amount of money directed in the SPD; and for delivery of the equipment in accordance with the contract schedule.

The SHAPM via the Ship Specifications requires the Shipbuilder to integrate the GFM as part of the overall ship system (installation design) and to receive, store, install, and perform checkout and tests for the GFM.

(3) Costs of Other Acquisition-related Factors Are Estimated By The Branch

Form NAVSHIPS 7130/1, included herein as Figure D.6A, is typical of the work sheet used by estimators to summarize their estimates of "End Cost." The End Cost is the grand total as shown

FIGURE D.6A

ESTIMATED COSTS FOR CONSTRUCTION/CONVERSION OF NAVAL VESSELS NAVSHIPS 7130/1 (REV. 10-66)

IDENT. NO.	ITEM	HARD CORE	PROJECTED GROWTH	END COST
111	CONSTRUCTION PLANS			
113	CONSTRUCTION PLANS CHANGE ORDERS			
121	CONTRACT PLANS AND WORK STUDY			
533	STOCK SPARES			
541	TEST & INSTRUMENTATION - H/M/E			
821	EIMO SYSTEMS INTEGRATION			
	SUB-TOTAL			
211	BASIC CONTRACT OR PROJECT ORDER			
213	REHABILITATION			
311	BASIC CHANGE ORDERS			
414	ELECTRONICS PROTOTYPE HARDWARE			
418	ELECTRONICS PRODUCTION			
452	ELECTRONICS DEVELOPMENT			
521	PROPULSION MACHINERY	GOVERNMENT FURNISHED MATERIAL		
525	H/M/E EQUIPMENT			
526	H/M/E PROTOTYPE HARDWARE			
553	H/M/E DEVELOPMENT			
563	OUTFIT MATERIAL - H/M/E			
1111	FUTURE CHARACTERISTICS CHANGES			
1112	FUTURE DELIVERY CHARGES			
2291	ESCALATION GROWTH			
	SUB-TOTAL			
711	POST DELIVERY			
813	ACCOMMODATION BARGES			
	SUB-TOTAL			
	NAVSHIPS ESTIMATED COSTS - TOTAL			
	NAVORD ESTIMATED COSTS - TOTAL			
	NAVAIR ESTIMATED COSTS - TOTAL			
	GRAND TOTAL			

☐ NEW ☐ CONV	SHIP TYPE	☐ LEAD ☐ FOLLOW	SCB	F.Y. PROGRAM
CONV. FROM		SHIPYARD		DATE

D-12740

on Figure D.6a. It is modified as needed by the estimator to include other charges or to exclude non-applicable items as circumstances may dictate.

The methodology of SEA 01G in estimating numerous factors not included in the basic contract estimate or project order, (IDENT. No. 211 on Figure D.6a) was reviewed and is briefly noted below:

- Identification No. 111. Construction Plans -- Cost Data is developed from similar ships. This includes costs, numbers of drawings, etc. which are projected by the estimator's judgment for current application.

- Identification No. 113. Construction Plans Change Orders -- A percentage of ID. No. 111 is applied for costs expected in outyears of the program.

- Identification No. 121. Contract Plans and Work Study -- Costs are no longer included against ships, but are covered by Research, Development, Test, and Evaluation (RDT&E) funds.

- Identification No. 533. Stock Spares -- Lists are provided by NAVSEC, PARMS, or other commands. Historical data and judgment are used to price out the furnished lists.

- Identification No. 311. Basic Change Orders -- Estimates vary by type of ship and are based on historical data. On lead submarines 16 percent of basic cost may be used (8 percent for hard core work plus 8 percent for growth). On lead surface ships, 12 percent may be used (8 percent for hard core and 4 percent for growth). Following ships at the same yard, or at other yards, will receive different reduced percentages.

- Identification No. 541. Testing and Instrumentation -- The cost is difficult to forecast from historical data, which is used as a base, as problems and progress of T. and I. vary from ship to ship in the same class. The estimator's judgment is used heavily to establish an estimate based on type of ship, the shipyard, etc.

- Identification No. 1111. Future Characteristics Changes -- The amount to use in the estimate is furnished by the Chief, Naval Operations. It may be "zero" to $10 million on a complex ship.

Other considerations in an estimate may cover models and mock-ups, inspection services, post delivery charges, etc. The estimating routing is similar to that described for the preceding items: obtain data from another organization, or the SEA 01G data bank, and modify it with judgment for current use.

Margins for various items may also be required to compensate for incompleteness of data, high risks, possible construction delays, changes and other factors known by experience which affect estimates adversely.

Although end cost ship estimates are the most important requirement of the Cost Estimating Branch, another level of requirements exists. The Branch does ship estimating for several other

purposes:

- Escalation estimates for all ship programs under contract are computed and projected quarterly to provide input for the single line item recently established in Congressional budgets.
- Profit estimates are made per applicable ASPR for each contract.
- Manhour estimates are prepared for ship conversions at Naval Shipyards.
- Special estimates for trade-off analysis and studies are prepared in considerable numbers for ship components, weapons, and electronics for various SHAPMs and PARMs.
- Ship Disposal estimates are made for surplus or obsolete vessels for the Naval Board of Inspection and Survey. (INSURV)
- Design to Cost Estimates. The Branch must estimate a ship with a variety of alternative characteristics to develop a cost, not to exceed a given dollar value. (Only one estimate has been required to date.)
- Should Cost Study. In cooperation with the DCAA at a given shipyard, the branch must make a detailed review and evaluation of the yard's operation in order to determine a reasonable cost of a ship or component to be built. (This has not been required to date.)
- Life Cycle Costs. The total cost of acquisition and ownership of a ship over its life span must be developed.

In recent years these tasks have been added to the Branch workload and there are several others being considered, as the Branch is a magnet for any project involving shipbuilding costs.

(4) Estimates Prepared by the Ship Cost Estimating Branch Are Classified as to the Level of Confidence Which Should be Placed in the Estimate

The amount of information available when an estimate is prepared obviously affects the quality of the estimate. OPNAVINST 7720.2 prescribes a standard method for classifying estimates so that those who use them will know how much reliance to put in them. These classes (A through F and X) are as follows:

- A - Detailed Cost Estimate (Post Budget-Contract Estimates) - estimate based on contract plans and evaluation of firm quotations for major material items.
- B - Bid Evaluation Cost Estimate (Post Budget - Contract Estimates) - estimates based on contract plans and evaluation of contractor proposals in response to an RFP.
- C - Budget Quality Estimate - estimate based on an engineering analysis of detailed characteristics of items under consideration.
- D - Feasibility Estimate - estimate based on technical feasibility studies and/or extrapolated from higher quality estimates of similar items.
- E - Computer Estimate - estimate developed usually by a computer model and based on cost estimating relationships and gross parameters.
- F - Ball Park Estimate - quick cost estimates prepared in absence of minimum design and cost information and based on gross parameters.
- X - Directed or Modified Cost Estimate - estimate not developed by SYSCOMS through normal cost estimating processes.

According to this classification system, estimates for ships without approved requirement or specifications (Top Level Requirements - TLR, or Top Level Specifications - TLS) will be class D, E, or F. Budget estimates are intended to be class "C" and a contract estimate should be class "B."

The review of a number of "C" class estimates prepared by 01G suggests that a more in-depth review should be made to determine whether estimates labeled "C" are, in fact, "C" quality, (i.e., estimate based on an engineering analysis of detailed characteristics of item under consideration). The definition of engineering analysis of detailed characteristics as generally interpreted by the private shipbuilding industry and other government agencies involved in major ship acquisition would include the following as a minimum:

- Preliminary Design (by Navy definition)
- Weight estimates in three digit breakdown for each ship system
- A complete equipment list for all components with a value of $10,000 to $25,000 (depending on ship type) and over
- In addition, because of a consistent record of naval program slippages, a capacity analysis of the industry should be made to establish realistic contract award dates and building periods.

The estimates thus far reviewed in SEA 01G are not prepared in this detail. In recognition of the present conditions under which estimates are made, if all estimates requiring "C" classification were done in this detail, the estimating organization would have to be much larger and more time would have to be allowed to make them.

(5) Techniques for Preparing Cost Estimates for the Various Necessary Purposes Differ

In Chapter II, the general requirements for estimates to support conceptual studies, programming and budgeting, and contracting were discussed. In this section the techniques used to develop estimates for these three purposes are described.

- Concept Estimates -- Estimates in the conceptual stage are based on very limited technical data which is generally provided by NAVSEC and the Project Manager. The technical data usually gives type, size, power, armament and some weight data. To develop these estimates, the estimator must draw upon cost data he may have developed on something similar, on his experience, and guidance received from cost analysis in his Division.

  Due to scarcity of technical data available, the estimator is limited to two techniques - analogous and/or parametric. The analogous technique would be used if the whole or major portion of the ship is similar to one built previously or under construction where cost or bid data are available. These costs are adjusted to ship or component size difference and to time. If the estimator is fortunate to receive weight data in the nine group breakdown he can use the parametric technique which involves no more than multiplying

the weights by the appropriate direct man-hours per ton for labor and dollars per ton for material. The concern here is first the accuracy of the weights, and second, development of the appropriate labor man-hour and material dollar factors. After the basic direct costs have been developed, the estimator must estimate the cost of engineering, decide upon a labor rate, overhead rate, profit margin and an amount for escalation during construction. Guidance is provided by the Cost Analysis Branch of 01G on such elements as inflation, overhead, labor rate, escalation, productivity trends and market conditions. With these additional factors determined, the basic ship cost is deduced. For the total end cost the estimator must add on the cost of electronics developed by NAVELEX and weapons from the appropriate program managers. If the ship is nuclear powered, nuclear component estimates will be provided by Code 08 (Nuclear Power Directorate).

This is one of the most difficult estimating assignments because of the newness of the concept and lack of specific product definition. The estimates are most important, however, because they are used in trade-off studies which have considerable bearing on the selection of new ship concepts and designs. Code 01G 11 does not keep records on the time spent on each estimate or project, but from staff interviews it is judged that during the last 12 months no more than 10% of the estimating effort went into conceptual ship estimates.

- Budget and Programming Estimates -- The estimates prepared for the Budget and the POM are treated by 01G as a continuing process. In the normal course of events, a new ship that has received CNO approval will appear in one of the "out" years in the FYDP. For example, in the 1978-1983 FYDP the new ship may be shown for the 1983 program. At this time, the estimated cost may be no more than an update of a previous estimate made during the planning stage, taking into account the program year, number of ships each year and upgraded technical data.

If a ship survives the selection process which reflects the influence of politics, fiscal constraints, threat changes and command preferences, it may ultimately be a candidate for the 1983 budget year. By this point, the estimate will have been refined, upgraded and looked at 4 or 5 times. The ship should have approved TLR and TLS along with an adequate weight breakdown. This should be sufficient to prepare a class "C" budget estimate.

The preparation of budget estimates for new designs that have never been built before will follow the same process as those prepared in the developmental stage except the technical data is better defined. In the majority of cases the ships in any one budget year are repeats of ships in a continuing program such as DD 963 destroyers, SSN attack submarines, or an aircraft carrier.

The estimate for these cases depends heavily on contractor bid data from previous contracts. From this bid data man-hours per ton and dollar per ton rates will be developed for each of 7 weight groups. These rates are then applied to the most recent corresponding weight estimate prepared by NAVSEC. The current weight estimate should include all changes made in the ship class and reflect modifications required for new weapon, electronic and other suits. The results obtained by applying the labor man-hour and material rates to these weights are then multiplied by an appropriate labor rate in $/hr. and the material cost inflated to the program year level. To the product of the labor calculation, overhead and profit are added which result in the basic ship cost.

The budget estimate, along with a statement of assumptions and qualifications, is then sent to the SHAPM where the appropriate budget documents are prepared. As the budget proceeds through the review process, SEA 01G will be called upon to make adjustments to their estimate, taking into account changes in the number of ships or even the insertion of new ships. From the command history covering SEA 01G activities, estimates were required for the POM/Budget cycle in 1976 for 13 programs involving 115 ships at a cost of $27 billion.

- Contract Estimates -- Estimates in support of contracting activities are prepared for the contracting officer so that he may judge the reasonableness of proposals and bids received from the shipbuilders.

At this time, much more is known about the ship since bidding plans and specifications have been prepared. The data is sufficient for the shipbuilder to request quotations for equipment and services, and prepare a detailed estimate for shipyard work.

To prepare the contract estimate, SEA 01G still uses the 9 group breakdown supplemented by equipment quotation. If available, SEA 01G will use return cost or audit cost returns on previous sister ships. These estimates are not in great detail and probably would not take more than a couple of days for an experienced estimator to prepare.

In distinction from the Independent Government Cost Estimate, the Government Contract Negotiation Objective is not an estimate so much as it is the government's alternative position to a company estimate. This is not to say that the government analyst will not benefit from knowledge and use of sound estimating techniques. However, the major effort is analysis of the company's techniques, using technical, audit and other evaluation methods. It is the one area where engineering estimating techniques should be used, particularly in the case of follow-on procurement where the price is based on the costs of a previous production run. The development of the negotiation objective is a part of the contract pricing process and the techniques are described in detail in the ASPR and in the Manual for Contract Pricing (ASPM No. 1).

The Deputy Commander for Contracts, SEA-02, is in charge of all contracting activities of the Naval Sea System Command. The Shipbuilding and Overhaul Purchase Division, SEA-022, specializes in negotiating and writing ship construction contracts, and in this capacity has a varying degree of contact with SEA 01G during several phases of the procurement process.

Return costs are supplied by shipyards on some contract agreements or by DCAA at shipyards direct to SHAPMS. They are sometimes available to SEA 01G for its estimating tasks, and SEA 01G would like to have all data that is available. At present, SEA 01G is not staffed sufficiently to analyze too many total accounts of this nature; but could scan them for a few principal material and labor costs to augment its data bank in weak areas.

The most useful direct role SEA 01G plays for contract negotiators is to furnish to them a contract cost estimate immediately before bid opening. As described previously, this is the most accurate estimate possible because of the availability of contract plans and specifications. It is prepared in the standard nine group breakdown form, Figure D.7, which also is used by the shipyards to summarize their bids. After bid opening, negotiators can compare the nine line items broadly for material, labor, overhead and profit and seek clarification where needed.

A detailed Technical Analysis Review (TAR) is also required as a pre-negotiation activity, unless adequate competitive bids are received. The TAR is conducted by a government team to evaluate material quantities and man-hours in the bid backup, which supports the nine group breakdown. Findings and recommendations are reported to the contract negotiator. Representatives of SEA 01G serve on this team to furnish supporting cost and production data, and to

FIGURE D.7

UNIT PRICE ANALYSIS - BASIC CONSTRUCTION

NAVSEA 4280/2 (6-75) (formerly NAVSHIPS 4280/2) (FRONT)

OMB APPROVAL NO. 45-R271

BIDDER	VESSEL	INVITATION NO. P.R.
ADDRESS		NO. OF VESSELS COVERED BY THIS UNIT PRICE ANALYSIS

	ITEM	DIRECT LABOR HOURS	DIRECT LABOR DOLLAR	DIRECT MATERIAL 1/	OVERHEAD	TOTAL
A.	ESTIMATED COST*					
100	HULL STRUCTURE					
200	PROPULSION PLANT					
300	ELECTRIC PLANT					
400	COMMAND & SURVEILLANCE					
500	AUXILIARY SYSTEMS					
600	OUTFIT AND FURNISHINGS					
700	ARMAMENT					
800	INTEGRATION/ENGINEERING					
900	SHIP ASSEMBLY & SUPPORT SERVICES					
B.	SUB-TOTAL - COST					$
C.	PROPOSED PROFIT % OF LINE B					
D.	GRAND TOTAL - UNIT PRICE					$

1/ DIRECT MATERIAL

A	DIRECT (Stores)	
B	PURCHASED PARTS	
C	SUBCONTRACTS (Major)	
1		
2		
3		
4		
	TOTAL	$

...is based upon or compiled from the books and records ... knowledge and belief.

NAME	TITLE
SIGNATURE	DATE

* See definitions on reverse

100 HULL STRUCTURE:

Shell plating or planking; Longitudinal and transverse framing; Innerbottom plating; Platforms and flats below lowermost continuous deck; Fourth deck; Third deck; Second deck; Main deck or hanger deck; Forecastle deck (including platforms, flats, and decks between main and gallery deck); Gallery deck; Flight deck, landing platforms and special purpose decks above weather deck (Includes catapult troughs); Superstructures; Foundations for main propelling machinery; Foundations for auxiliaries and other equipment; Structural bulkheads; Trunks and enclosures; Structural sponsons; Armor; Aircraft fuel saddle tank structure; Structural castings, forgings, and equivalent weldments; Sea chests; Ballast and buoyancy units; Doors and closures, special purpose; Doors, hatches, manholes, and scuttles, nonballistic; Doors, hatches, manholes, and scuttles, ballistic; Masts and king posts; Compartment testing.

200 PROPULSION PLANT:

Boilers and energy converters; Propulsion units; Main condensers and air ejectors; Shafting, bearings, and propellers; Combustion air supply system; Uptakes and smoke pipes; Propulsion control equipment; Main steam system; Feedwater and condensate systems; Circulating and cooling water system; Fuel oil service system; Lube oil system.

300 ELECTRIC PLANT:

Electric power generation. Power distribution switchboards; Power distribution system (cable); Lighting system distribution and fixtures.

400 COMMAND & SURVEILLANCE:

Navigational systems and equipment; Interior communication systems; Armament control systems; Countermeasure and ships' protective systems (except electronic); Electronic systems including electronic countermeasures.

500 AUXILIARY SYSTEMS

Heating system, Ventilation system; Air-conditioning system, Refrigerating spaces, plant and equipment; Gas, HEAF, cargo piping, oxygen-nitrogen, aviation lube oil systems; Plumbing installations; Firemain, flushing, and sprinkler system; Fire extinguishing systems; Drainage, trimming, heeling, and ballast systems; Fresh water system; Scuppers and deck drains; Fuel and diesel oil filling, venting, stowage, and transfer systems. Tank heating systems; Compressed-air systems; Auxiliary steam, exhaust steam, and steam drains; Buoyancy control system (flooding and venting - submarines); Miscellaneous piping systems; Distilling plant; Steering gear system; Rudder; Winches, capstans, cranes, and anchor handling system; Elevators, moving stairways, and cargo handling equipment; Operating gear for retractable elevating units; Aircraft elevators; Aircraft arresting gear barriers and barricades; Catapults and jet blast deflectors.

600 OUTFIT AND FURNISHINGS:

Hull fittings; Boats, boat stowage and handling; Rigging and canvas; Ladders and gratings; Nonstructural bulkheads and nonstructural doors; Painting; Deck covering; Hull insulation; Storerooms, stowages, and lockers; Equipment for utility spaces; Equipment for workshops; Equipment for galley, pantry, scullery, and commissary outfit; Furnishings for living spaces; Furnishings for office spaces, electronic, and radar; Furnishings for medical and dental spaces.

700 ARMAMENT:

Guns, mounts, and launching devices; Ammunition handling systems; Ammunition stowage; Special weapon stowage and handling.

800 INTEGRATION/ENGINEERING:

Design and engineering services.

900 SHIP ASSEMBLY & SUPPORT SERVICES

Staging, scaffolding, and cribbing; Launching; Trials and docking; Temporary utilities and services; Material handling and removal; Cleaning ship services.

act as liaison between Navy and DCAA team members.

(6) Various Problems Are Apparent In The Ship Estimating Branch

The review disclosed a variety of problems in the Ship Estimating Branch which do affect the attitude of the personnel and, in some cases, must affect the quality of the products.

- A major concern of the supervisors is the shortage of experienced and qualified staff. This includes a lack of depth which requires supervisors to be more worker than supervisor. Currently this shortage is illustrated by the fact that the estimator during the FFG program took a job with the FFG SHAPM and took the estimating function with him. As another illustration, the position of Head of the Estimating Branch has been vacant since 1972,* which places undue pressure on the Director of the Division and Section Supervisors. Loss of objective reviewing by a Branch Head is a serious disadvantage in a Branch where lack of time and depth exist.

- Poor product definition is a major concern. Estimators feel they are being required to produce budget quality estimates with incomplete or unapproved characteristics. An inadequate estimate is produced and, because of unexpected and untimely changes in programs, may be used for budget purposes. Once the estimate is locked in, SEA 01G is at a disadvantage to refine it as more or firm characteristics become available. A worse problem develops when a quick estimate is requested for an unprogrammed ship, with miniscule definition, and, because of exigencies, gets into a current program and a budget.

- A procedure is lacking for getting detailed bid data and returned costs in a form to be used in developing future estimates. An inherent problem with bid data is that

* Position filled June 1977 by promotion without an increase in staff.

back-up details are not required by ASPR to be provided on ship contracts for which there is sufficient competition.[1] On some sole source procurement Contract Negotiators in SEA 02 do not obtain the required bid data. Both factors result in unavailability of current data required by SEA 01G for best estimating.

Most bid data, when available, is in the shipyards' forms, and requires detailed analyses and conversion into SEA 01G's format. There is no personnel available for this large task. Returned costs also are submitted by shipyards' accounting systems and are not timely. The following Table D.7 reveals that the shortest interval between a budget estimate for a ship and the returned cost is three years, and it can be as long as nine years.

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1. Of particular interest on this point is that the Merchant Marine Act of 1936 (administered by Maritime Administration, Department of Commerce) and all amendments require that detailed bid back-up data be given to the government on all competitive bids prior to contract award.

TABLE D.7

DELIVERY SCHEDULE FOR SHIPS IN PROGRAM YEARS 1972 - 1976

Program Year	Estimated In	Number of Ships to be Delivered							
		1976	1977	1978	1979	1980	1981	1982	1983
1972-73	1970-71	2	6	7	5	3	-	-	-
1974	1972	-	-	6	2	2	4	-	-
1975	1973	-	1	1	7	11	1	1	-
1976	1974	-	2	8	3	8	4	1	1

Source: Financial Status Report as of September 1976. NAVSEACOM.

Some other system is urgently required for provision of returned costs. Periodic visits by SEA 01G personnel to DCAA offices or periodic transmittal of interim DCAA reports would be very helpful; but only more personnel could do a proper job.

- Many of the staff are concerned about command recognition. This feeling comes about because SEA 01G is a service organization to all SHAPMS with whom they deal on a daily basis and upon whom they are dependent for certain costs and technical data. The estimator in providing his service very often receives SHAPM pressure to take margins out of his estimate, even though almost all estimates on the basis of preliminary data have been low.

- All were of the opinion they did not have time to do as good a job as they were capable. They are encouraged to adopt the "can do" approach as a means of accomplishing the requirements. Their deadlines for budget estimates must be met; however, the POM or prices for weapons and electronics have been sometimes late in arriving.

Supervisors work on estimates to respond on time, thereby destroying same of the necessary objectivity to review them properly. Sometimes the deadline is shortened to cause a further pressure on time. Many requests for estimates other than budget types are received officially and many more by telephone for quick answers. Interruptions for key personnel are a normal occurrence, as witnessed by first hand observation on numerous visits to the Division.

- The workload is increasing. In November, 1972, the SEA 01G was reorganized with expanded responsibilities. In 1972, budget estimates were required for 21 separate designs consisting of 166 ships at a cost of $18 billion. This output was considerably higher than the previous year's. In 1976, the workload had grown to 31 separate designs for 180 ships which were estimated at a cost of $43 billion. Additionally, many nonbudgetary estimates have been made and their numbers are increasing. Many economic analysis functions, which will be described later, have been added progressively. Estimates for the following items are more recent additions to the workload:

  - Metrication
  - Pollution abatement
  - Occupational Safety and Health Act (OSHA)
  - Equal Employment Opportunity Act (EEO)
  - Energy pass-through costs
  - Survivability of weapons

  Techniques for making estimates for these items are under development as information is received.

- Growth of duties further taxes the time of estimators. Recent personnel changes consisted of younger people without previous experience replacing experienced departing personnel, which added to pressures on key personnel. The employment practices are now requiring that SEA 01G take into their training program some personnel unsuited for the work. Also the grade structure is such that they are losing good people. This will be illustrated later by a graph which was developed from personnel records in 01G. Anticipated changes in 1977 indicate a continued downward trend of grade structure. The grade structure is not conducive to retain a staff which has 91% college trained people, many with advanced degrees.

- Estimators have expressed concern that they very rarely see a ship or visit a shipyard. An audit of current personnel in SEA 01G revealed that only three estimators out of 13 had significant shipyard experience. Among the analysts only two out of eight had very brief tours of duty in naval shipyards. Some personnel in both branches had a mix of other construction experience or shipboard service, but overall the staff has not had and is not getting sufficient exposure to the work it analyzes and estimates. Practical observation is considered a necessary background for appreciating and applying available data and analyzing detailed bids and returned costs.

- Estimators are restricted from best judgment on some factors by regulations and policies.

    - Despite a long and convincing record of delays in ship deliveries estimators must restrict their computations to the predetermined contract construction period. They cannot add sufficient margins for escalation, labor rates, etc. to cover expected increases attributable to longer building periods.

    - They must provide reductions in material and labor estimates for learning on multiple ship contracts although no basis for such reductions may exist at the time.

- No provisions for contingencies, other than cost growth for change orders, are permitted in an estimate. Recent contract history indicates that it would be prudent to do so.

- There is a pressure from higher levels to reduce margins for elements of cost growth. Estimators feel that margins should reflect experience, which shows that "estimates are always too low and real costs are always too high."

- The data bank for weapons and electronics is poor. When the estimating section for combat equipment was organized in 1974, there was no data bank. It is slowly being built up from annual lists provided by other commands, but these lists do not provide details necessary for confident estimating. Eventually, parameters should be computerized to make all data available for estimating purposes.

- The data bank for ships needs upgrading.

  - In 1972, a new ship work breakdown (SWBS) was established. Conversion of past data for this system is done by computer only upon request of estimators. As this is time consuming and may come in an inconvenient period, conversion of data at least for the most costly types of vessels should be done to have it available for future use.

  - Old bid summaries and cost reports are on microfilm, but current data are not. The record is at a level of 85% and should be completed to promote quick retrieval of more valuable recent data. Computer programs for economic data such as inflation and escalation, and financial data for overhead and profit, etc. are at various stages of completion. The most important ones should be finished and kept updated to promote accuracy for estimators on a current basis. The estimators seem to be bothered by an inability to get some data and that they must go dig out the data themselves rather than be supplied it by certain sources.

- A computer program for centralizing estimating parameters data should be established for principal categories of hull and machinery costs by type of ship, to make total data available promptly.

- Records of the division should be completely listed and indexed for information and location. Each section possesses material such as directives, texts, reports, etc. in cabinets; and individuals have similar information plus personal files. Every member of the staff, especially newcomers, should be aware of the total library and data bank to facilitate work and save time.

. Other problems were reported by the staff during desk interviews and are noted here for information:

- Too many diverse functions
- No feedback on estimates
- Insufficient data on GFM
- Working to a predetermined cost target
- Keep price low
- Poor product definition
- Not enough returned costs
- Need priced purchase orders
- Constraints on hiring
- Discipline on cost inputs is not enforced
- Need three digit cost breakdowns

In summary, the most frequent complaints related to insufficient time to do or revise work and to insufficient data as to quantity and format.

3. THE COST ANALYSIS BRANCH (SEA 01G2) PROVIDES THE DIRECT ANALYTICAL SUPPORT TO SHIP COST ESTIMATORS

The Cost Analysis Branch of SEA 01G was established formally in 1969 to provide direction to the cost estimators by providing in-depth analysis and guidelines of specialized cost elements. There was no organized effort to contribute information into a comprehensive compilation of standardized form. In the absence of a uniform data guidance system, users interpreted available records per their own judgment. The SCN Pricing and Cost Control Study of June 1969 made a recommendation that the cost analysis capability be increased to improve estimates because of this obvious defect in the observed system.

An initial staff of four analysts was created and assigned to collect pertinent information within Navy, from shipbuilders, equipment manufacturers, other government agencies, trade journals, business analysts, etc., in a defined systematic manner. Coverage of these sources expanded continuously as the staff increased to thirteen analysts in 1970. Cutbacks to accommodate personnel policies reduced the staff to nine by 1976, and the Branch is not functioning at full potential.

Early in 1976 an econometric service was obtained, as an additional guide to the Cost Analysis Branch for its economic analyses and projections for materials.

On an annual basis the Cost Analysis Branch provides the following in-depth analysis guidelines to the Cost Estimating Branch for use in preparation of cost estimates.

- Material inflation trends
- Labor rates and inflation trends at commercial shipyards
- Labor rates at Naval shipyards
- Material escalation during life of contract
- Quick estimate of escalation
- Small boat escalation
- Overhead rate trends at commercial and Naval shipyards
- Productivity trends
- Market analysis (probable bidders)
- Profit trends
- Costs of social legislation
- Costs of Metrication
- Pollution abatement
- Out-year guidelines

Most major subjects listed above were examined through personnel interviews, inspection of resources used, and studies of outputs. Observations will be made subsequently.

The Cost Analysis Branch also has a variety of functions and tasks, which do not fall into annual cycle patterns. Some of these, which are discussed subsequently in greater detail, are:

- Economic Forecasting
- Economic Analysis
- Life-cycle cost studies
- Design to cost studies
- Should cost studies
- Technical Analysis Review (TAR)

- Instruction at seminars and courses
- Participation in intra-governmental studies of indices
- Analysis of cost studies by other agencies

(1) Material Inflation (Basic Construction Cost)

Material inflation is the upward movement of commodity prices in the economy. It is an essential consideration for estimating current or future material costs from historical data. There was no uniform guidance provided prior to 1969, and estimators used judgment on available information in existing central or personal files.

In 1970-71, brief material guidance based on Bureau of Labor Statistics (BLS) data was included in an expanding package of guidance information.

The mix of materials used in these BLS indices is not representative of naval shipbuilding materials. It consists of the following and was inadequate for the purpose of accurately predicting inflation: WPI-10-1 iron and steel -- 45 percent; WPI-11-7 electrical machinery -- 15 percent. The formula was developed by the Maritime Administration in the 1950's for commercial vessels and is still used for computing contract escalation for naval vessels primarily because it is accepted by the shipbuilder.

The Office of Secretary of Defense, Comptroller OSD(C) has recognized that the usual commercial price indices do not always apply to defense contracts. The OSD(C) contracted with the Bureau of Economic Analysis (BEA) to develop price deflators for the purchase of military equipment. The results of this study are to be submitted in November 1977 and is formally titled "Defense Price Index Project."

NAVSEA 01G worked with the BEA in developing a methodology to improve price measurement of shipbuilding and specifically initiated a "notional" ship concept. Under the notional ship approach BEA is developing a completely new material index based on inputs from marine vendors, wholesale price indices and other price lists for generic materials commonly used in shipbuilding. The "notional" approach yields the most accuracy since no subjective cost adjustments are made for quality changes. The specifications remain unchanged, thus the same "quality" ship is estimated annually. It is anticipated that this approach will provide the shipbuilding industry and the government with a more realistic index than the one now being used.

In 1972, the Cost Analysis Branch abandoned the inadequate BLS data system and began to formulate its own index for predicting inflation using several separate groupings: hull steel, propulsion

machinery, electrical power equipment, electrical wire and cable, auxiliary systems, command and surveillance systems, and outfit and furnishings. (The grouping was derived from a relatively new Ship Work Breakdown System.) Starting with no data bank, it obtained data from 12 vendors in 1974 and added some general market information for use of the estimators. By 1976, material inputs were greatly expanded covering data from ten shipyards and 146 vendors. Many more requests were made of other vendors, but they were ignored. Industrial publications, such as "Iron Age," and manufacturers' catalogs are used to verify data on hand or to obtain data not available elsewhere. Additional sources include in-house contract estimates and change order estimates. More data is desirable but it is difficult, if not impossible, to obtain from some segments of industry.

The latest completed material guidance was applied on ships in the FY 1978 program. For analysis of past material estimates, it was adjusted back to 1965 as the base year for escalation indices by inputs of actual costs. This exercise provided a corrected trend line for projection into the future. For general reference, movements of the former BLS material index are given for the entire period. Additionally, many examples of unit costs are furnished in narrative

form to give estimators specific data upon which they may exercise their judgment.

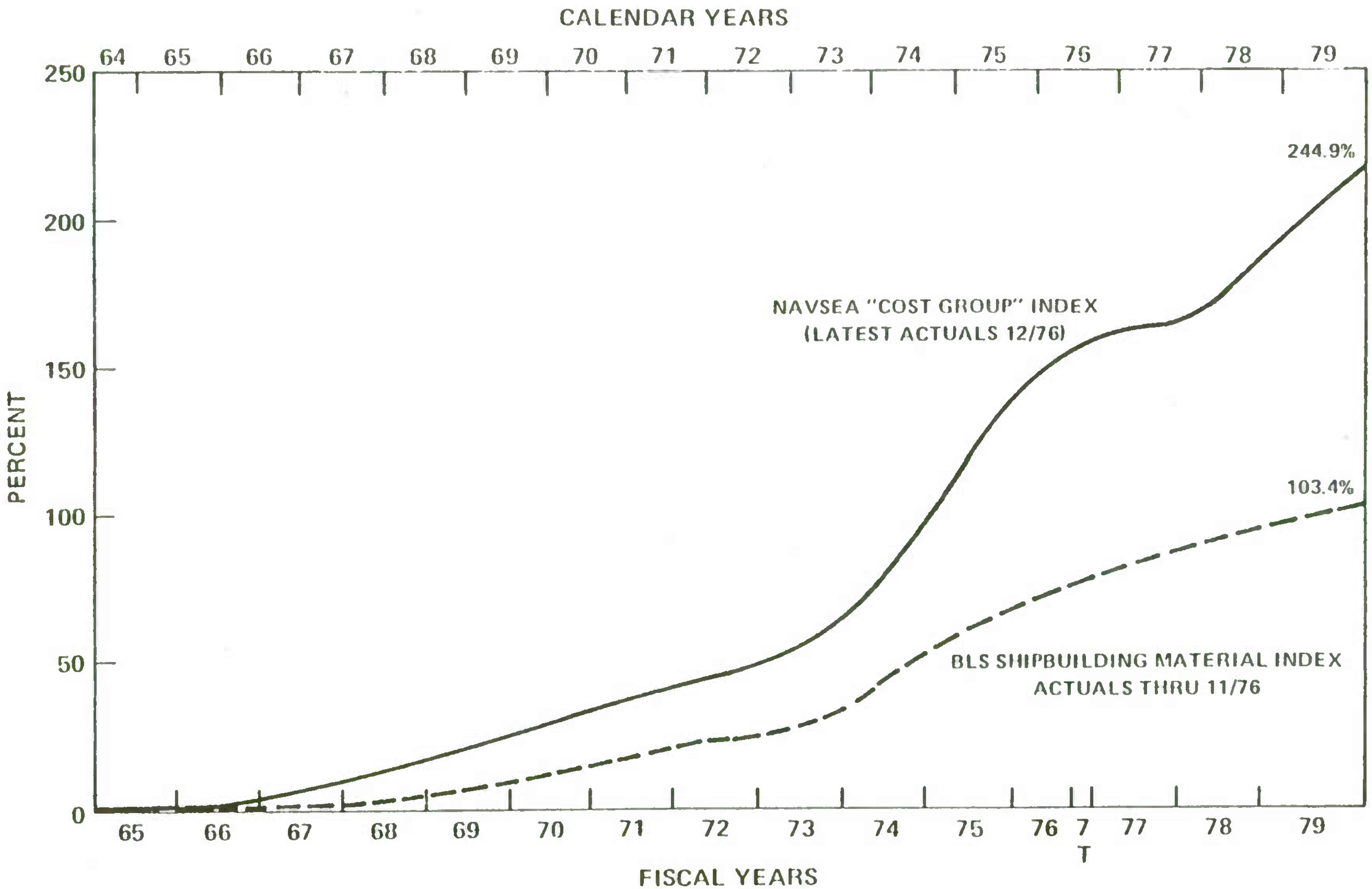
Figure D.8 shows the difference between the overall composite BLS index for commercial materials and NAVSEA's shipbuilding material index described above. Usage of the upgraded index tailored for naval shipbuilding materials will result in more accurate material cost estimates. It is apparent that past reliance on the BLS index resulted in insufficient cost adjustments to estimates on ships now under construction.

In a relatively short period of time the Branch produced superior material inflation guidance, which is issued on an annual basis. When conditions warrant, supplements are issued during the year on pertinent matters. Efforts to improve the guidance continue. The Branch requires more responses from industry. Priced purchase orders would be especially helpful. Additional data for electronics, navigation aids, etc. from Navy procurement offices are needed. The following suggestions relate to this effort.

- Obtain an additional source for prices of alloy steel, electrical cable, and main reduction gears.
- Avoid catalog prices and obtain actual quotations or returned costs for main turbine propulsion sets and diesel-generating sets.

FIGURE D.8

MATERIAL COST GROWTH AND KEY PROGRAM DATES FOR SHIP CASES



- Obtain at least one source for main condensers.

- Include non-ferrous and stainless steel pipe prices in the piping list.

- Provide prices for a representative number of galley and messing items.

In the absence of routing industrial sources for the above items, the Branch should solicit information from Navy auditors at private and its own shipyards. A visit to an on-site audit office for examination of accounts could produce even more missing or supplementary cost information for improving the guidance. Other government agencies involved in shipbuilding programs also should be contacted, as possible sources of current cost information, on materials for which data is unavailable routinely.

Additional data collecting and its processing would require additional personnel.

Material inflation guidance output grew from one page in 1970, to reorientation and emphasis in 1972, and to 18 pages of analysis in 1976. The composition and coverage after allowance for certain shortfalls which were previously mentioned are near an optimum level for requirements of estimators. Computation, tracking, and forecasting techniques are considered to be proper and adequate

for the results required by estimators, who must still use them with judgment in their work.

(2) Material Inflation - Government Furnished Material

Depending on type of ship, the costs of GFM, primarily ordnance and electronics, vary between ten percent and 30 percent of total ship costs. Since these costs are provided as inputs by other offices and system commands, they vary in the quality of inflation factors. The Cost Analysis Branch in the past has not endeavored to second guess their projections although SEA 01G has provided guidance to estimators for material inflation on these items.

Prior to 1974, the Cost Estimating and Analysis Division received material estimates for ordnance and electronics items from various Navy sources and inserted them into line items of estimates without modification. In 1974, a Combat Systems Cost Estimating Section SEA 01G13 was organized by transfer of three weapons and electronics cost estimators from other system commands. This Section validates inputs, estimates alternatives, etc. as described previously. Basic data for its use continues to be provided by other Navy offices.

As a result of the significant inflation, and material and energy shortages that occurred in 1974, the Cost Analysis Branch was generally uncertain about provisions for inflation in cost data received from others. It questioned its presence and/or amount, and concluded that there now is a greater responsibility than before for making adequate provisions for such inflation.

A special guidance was compiled in 1974 entitled "Inflation for GFM Equipment" for use by estimators to ensure that adequate inflation projections were used. As broad-based "procurement indices" furnished by Office of Secretary of Defense were considered to be too low, the Branch selected the BLS shipbuilding index and a 50-50 material and labor split to construct an inflation table for weapons and electronics awards from 1974 to 1985.

As noted before, the Branch considers the BLS index as inadequate for ship estimating purposes. Its inadequacy is undoubtedly greater for highly specialized and sophisticated equipment, but because of insufficient personnel, the Branch does the best it can within the resources available.

Use of the guidance by estimators can produce uncertain results. If original input data already provides for inflation which is

not identified, application of an additional factor pads the estimate. If it does not, the applied inflation correction is admittedly minimal on a doubtful index.

The present capability for accurate estimating for government furnished material must be classified as uncertain. Since the cost portion of these items on a ship can be high, a substantial error in end cost can result. The first action to alleviate this situation is to obtain complete documentation of input data from Navy sources. This must be followed by the construction of an appropriate inflation index for such equipment based on breakdowns furnished by vendors.

(3) Labor Rate Projections

Prior to 1970 estimators relied on historical bid data for a base upon which to predict a labor rate for budget estimates. Each estimator updated the base through more current personal data or sources available to him on a case by case basis for projecting future labor rates to time of contract award.

Since 1970, the Branch produces an annual format guidance table for use of estimators in selecting labor bid rates to apply to

labor hours estimates on ships anticipated in the budget two years hence. Resources for this task are about 80 union-management agreements, Bureau of Labor Statistics, historical bids, U.S. Department of Commerce (MarAd), Naval Shipyards and other sources. The guidance promotes consistency in all estimates and narrows the margin of error over the previous personalized methods.

From the input data, expected production, engineering, and composite labor rates are established for commercial shipyards. These reflect factors such as overtime, piecework, and incentive payments, as derived from past bids. Up to three analytical methods of determination can be used, and the analyst's judgment is exercised for the final selection of most representative rates. Current guidance reports are for five shipyards on the East Coast, two shipyards on the Gulf Coast, three shipyards on the West Coast and for two "inland" shipyards, which are on the Great Lakes. Coastal and national averages also are given in the guidance. Labor rate projections for other yards are available on a case by case basis. The analyst provides a narrative analysis for several of the largest shipyards to show the basis of his labor rate predictions, time frame of the applicable labor contract, etc. for further

guidance to the estimator.

Composite labor/overhead rates for the various Naval Shipyards also are established from inputs by the various yards. These are furnished in the annual guidance for budget estimates principally on conversion and repair projects.

The type of ship being estimated coupled with the current market condition often permit an estimator to limit application of the labor rate guidance to specific most-likely-to-bid shipyards or, if circumstances warrant, he has the option of using coastal or national averages. The overall judgmental factor is reduced, however, as it was exercised principally by the better informed analyst in arriving at his predicted rate structure and the market situation.

The technique employed to forecast future labor bid rates is thorough and consistent. Most data resources used are the best available; hence the resultant estimating guidance is good. Greater accuracy can be achieved, however, in two areas:

> Reliance on historial bids for basic ratios of overtime, piecework, etc. should be minimal. Older bids may not reflect changes caused by current facilities, management policies, and labor agreements, and will present an erron-

eous base for evaluating adjustments on future labor rates. Also, some former details of bid data are recognized by analysts as inaccurate, with a general adjustment made to the final totals to achieve overall accuracy. Every effort should be made to obtain current actual labor adjustment data from shipyards listed in the guidance report. Navy auditors should be able to supply it at least annually, if it cannot be obtained directly from the shipyards.

Since bids and costs could be received for many ships included in budgets a few years following the budget estimate, the Branch should routinely check its former predictions to determine if initial premises require refinement or modification. To our knowledge this is not done on a systematic basis.

The Bureau of Labor Statistics studied shipbuilding wages and related fringe benefits in September-October, 1976, and will publish results in 1977. Since the study was based on straight time wages by craft it may have only limited value for the Cost Analysis Branch, which requires actual adjustment data for premium pay factors to apply to straight time wage data in its possession. Data provided from the study of craft mix may be useful for improving the composite labor rate predictions.

(4) Overhead Projections

There was no systematic or thorough method of determining overhead rates for shipyards prior to 1972. Cost estimates referred to a central file for past data on shipyards being considered, and

selected overhead rates for current estimates based on their individual knowledge, experience and judgment.

In 1972, the Cost Analysis Branch began its formal analytical system for providing specific guidance on overhead. Its objective was to predict the rates which each yard would use in its bid estimates two years in the future. Estimators could study this information to determine the one overhead bid rate to use in a budget estimate for the entire building period of ships in the contract being considered.

Past bid information from various sources was analyzed for known current conditions for 125 shipyards and boatyards throughout the country. Resultant overhead rates were included with labor rate information for selected yards on the annual guidance forms established in 1970. Estimators could now compute consistently the intended average overhead bid rate for any of these yards considered likely to bid. The number of yards included in subsequent years' guidance varied with market conditions. In 1976, twelve yards were listed.

A more in-depth analysis of actual overhead accounts at several major shipyards was conducted in 1974 by the Cost Analysis

Branch with data supplied by the Defense Contractors' Auditing Agency (DCAA). In 1976, based on the data obtained, a computer model consisting of 130 items was developed for one shipyard. Later in 1976, a similar, but smaller model was completed for another shipyard. Work is underway on additional models, as resources permit, because the Branch desires a model for every major shipbuilder in the country.

Projections of overhead costs for other yards in the annual guidance are established by continued trend analysis of gross quantities using current inputs from DCAA and recent bid data. This method is the best available in the absence of detailed models. Up-dating of information for the existing two overhead models also forms a basis for more accurate determinations of trends at the other yards. Ability of the models to be extrapolated up to six years improves the grade of trend analysis for the same period, although by any method a six year prediction is of doubtful value.

Overhead accounting systems vary among shipyards and are not static in any yard. Several changes can be expected in each year. Additionally, to get an accurate projected overhead rate, the analyst must have an accurate input of labor costs at each

yard far the denominator of the equation. He must supplement whatever information he has on labor far Navy ships, by data for current and future commercial ships and industrial work. To a large extent he obtains the non-Navy ship data from the Ship Production Office, Code 075, in NAVSEA, which tracks commercial ship construction via the Maritime Administration. There is no easy way to obtain the scope of industrial wark. In order to make a realistic appraisal of pending private work personal contacts must be made with the private sector of the industry, as the informatian is seldom published nor is it otherwise readily available. The actual overhead rate for a shipyard varies constantly and yards account it on a monthly basis. To keep abreast af developments, far possible changes to the format annual guidance, the Branch monitors and adjusts its data and amends its forecast as needed.

Because of the dynamic nature of pertinent known elements, a precise overhead figure for the life of a contract is elusive. To further compound the problem several recent developments detract from accuracy:

> Fringe benefits are rising faster than labor rates. Industry-wide, fringes were about 25 percent of labor rates about two years ago. At one shipyard, the current rate grew

to 43 percent. Such growth can upset a relatively recent overhead prediction.

The Maritime Administration noted that fringe benefits rose from 25 percent to 35 percent in 1976 at some shipyards. As a result, BLS was requested to study fringe benefit costs in connection with the shipbuilding wage study mentioned previously. A report is expected in 1977.

Changes in Social Security taxes, new environmental regulations, increased safety standards, etc., were unpredictable a few years ago when budget estimates were made for work now under contract. Even now, the possible cost of these developing requirements has not been determined for application in future budget estimates. Guidelines are being furnished to the Branch as they become available.

Cost of energy has been a normal overhead item. The market is so abnormal that special provisions must be made to pass additional costs on to the customer. In some new contracts, escalation on overhead is provided, which would cover increased energy costs automatically.

Labor turnover and absenteeism have increased tremendously in the past few years. A related activity includes increased training to combat shortages of skills. All three are overhead cost items which cannot be predicted accurately.

At least two years' cost experience and the forthcoming BLS report are needed for analysts to incorporate supportable corrections to overhead computations for the factors listed above. Until then the analyst's judgment must be applied to update the overhead rate guidance.

The latest national overhead average for principal yards doing Navy work is 105 percent, with a range of 70 percent to 144 percent; and the trend is upward as noted above. Total cost of overhead can exceed labor or material, or both on some types of ships. Accurate forecasting is growing in importance, yet the difficulty to do so is increasing.

The Cost Analysis Branch has made substantial progress in collecting data and developing analytical methods for overhead guidance since 1972. It keeps up-to-date on many matters and seeks out new information to improve its output. Computers are utilized for frequent and rapid outputs.

Construction of additional models continues as time permits. Unfortunately, the Branch does not keep a record comparing forecasts to actual results; hence, it cannot demonstrate the effects of improvements nor make solid conclusions from such comparisons for use on future work. Lack of time is cited as the reason for not establishing such a record. (The overhead guidance is done by only one analyst.) Time should be found for this task and a few others listed below, for which additional personnel should be assigned. They should be qualified in accounting for analysis of changes in

overhead structures, pro-rations, etc., which are constant. Other functions the Branch can do to improve its guidance are:

Continue development of overhead models under construction as soon as possible.

Increase detailed current data base from shipyards, preferably by personal visit to Navy's audit offices on job sites to discuss trends of various elements of overhead.

Determine shipyards' plans for future major facilities and include associated costs in projected overhead computations. This has not been done to date even though some yards have had extensive modernization programs, with intended 3-10 year amortization periods.

Provide for overhead costs for extension of contract construction periods per realities dictated by recent experience. The present seven month delay assumption is inadequate for establishing a margin in most cases.

Establish routine liaison with the Maritime Administration and other agencies for regular exchange of overhead and labor costs at shipyards doing Navy and commercial work.

Commence forecasting overhead for the larger GFM suppliers.

Continuation of progress in quantity and quality of data resources should be stressed because of the increasing leverage of overhead in estimates. Even in an optimum system consistent predictions within 5 percent of actual for a multi-year building period are considered to be the limit of accuracy because of the fluctuating and dynamic character of many elements that are involved in overhead

computations and the unpredictable energy market.

All that can be expected from the analysts is that they include every significant influence on overhead that is possible and project it on a sound basis. Their rating on this score increased from poor to very good in a four year period. It could become optimum in two more years, if additional personnel with the proper backgrounds were added to implement previously suggested functions.

Judgment of analysts in the overhead predictions and judgment of estimators who use the guidance are not infallible, and they may be victimized by unexpected events of the economy, as has been frequently the case in the past. However, it can be enhanced by processing more information through proven analytical methods. Judgments should be evaluated by annual comparison with results and the system adjusted as needed to further advance the accuracy of predictions.

(5) Contract Escalation

Escalation contrasts with inflation in that it is the rise in costs experienced during a contract period as measured by agreed terms. It is a function of inflation in that period but may not be

equal to it because of the applicable contract provisions and the indices used to measure the cost fluctuations.

Throughout the 1950's the Navy did not budget for total escalation but estimated the dollar payout on a yearly basis. Each year a projection was made by the cost estimators as to what would be required to pay for the escalation in the existing contracts for that year and that amount was added to the budget.

In the early 1960's, in order to comply with the Full Funding Statute, the Navy cost estimators began to estimate the total cost for escalation on a gross overall factor applied to the total SCN expenditure, instead of to each ship program, and included the total cost in the budget.

In 1971, because of the recently introduced "ship end cost" concept, escalation was estimated and applied on each ship program. This estimate is based on a forecast of individual payments over the bidding period per contract clauses. The forecasted amount had to be approved by OSD for each budget submittal. The projections were usually revised downward by the Navy Department and the Office of the Secretary of Defense. In 1971, for instance, Navy

wanted to use a 5 percent per year projection for BLS material, but OSD revised it to 3.5 per cent. Ships involved are now under construction in the 1973 program and are showing escalation several times greater than forecast. Subsequently, the Branch had to use the OSD guidance, even though it was considered to be inadequate for the times and needed revision.

To achieve the revision, an analytical method for predicting the indices was developed by the Branch several years ago. Because of their demonstrated improved accuracy, the projected indices have been approved by OSD since 1974 without modifications. From the provided breakdown OSD's Comptroller issues a composite annual directive known as the "McCleary Indices" for use by Navy, but the Branch finds its own basic breakdowns more convenient in its work.

In 1972-1973, a computer-oriented system was developed by the Branch for calculating the escalation costs for budget estimates. The first runs were made in 1973. Estimators provided estimated material, labor, and overhead costs for each ship to an analytical team. Contract escalation clauses were translated into formulae. By 1976, several programs had been written and used

for over 100 ships under construction. Because of variations in base year, material and labor distribution curves, cost of energy provisions, type of escalation clause, etc. each ship program is an individual one. The set-up of data and making computer runs are done for the entire range of requirements by two analysts who are computer specialists responsible for all escalation programming done in the Branch. Their workload is too high, so additional staff would be very useful in maximizing the unit's value, not only for escalation budgeting, but for accounting, cost trade off studies, etc. About 150 runs are made per month for ship programs and an additional 50 runs are made for related matters. (This compares to an average of 10 exercises that were produced each month previously by hand methods.)

To respond to numerous requests for approximate escalation estimates the Branch also has developed a "quick answer" method in 1974. It is worked out by hand to produce answers for a variety of drills and purposes not requiring full processing of a program through the computer.

Two basic escalation clauses are in effect on Navy's ship contracts. The clause written in 1962 applies to most ships being

built now. It restricts payments to the contract scheduled delivery date, on a quarterly basis, in accordance with a pre-established apportionment of labor and material expended which did not include change orders. These restrictions were criticized by shipyards as inequitable for actual conditions, and resulted in some claims. A major revision known as the "1975 Clause" was issued; it is also referred to as the "Marshall Clause". It provides for monthly payments on actual material and direct labor expenditures plus a pre-determined percentage of overhead, including change orders, through the actual delivery date, but not to exceed the contract ceiling for labor and material, as adjusted for changes.

Both the 1962 and 1975 clauses rely on the Bureau of Labor Statistics indices for adjustments of material and labor compensation throughout the contract period. These are being used despite their defects because they are considered by Navy and some contractors to be the best available. (The Cost Analysis Branch uses its own index for material inflation forecasts on estimated contract material costs up to contract signing, but it cannot be used for contract material escalation because it is not a contractual provision.)

Since escalation tasks deal with future events and economic factors, and as BLS indices upon which these will be based are only historical, it was necessary to make predictions for the behavior of BLS indices in the future. The present method was developed in 1974. They produced a forecast of tables, graphs, and narratives for guidance of the escalation analysts. It is prepared annually to show latest actual BLS indices and to forecast them for a minimum of four years. Extrapolation for longer-range forecasts is by extension of the four-year trend curves. The labor index is predicted similarly to the method that BLS develops its historical index, with labor rates at 16 shipyards obtained from the labor guidance described previously. The material index forecast is also based on BLS format for steel but utilizes more judgment and statistical methods by the analyst, as data for the near future is not as available as for labor rates.

The NAVSEA in-depth projections of these indices were developed only for the past three years. Results are shown on historical curves. Actual BLS indices for a prior year are substituted for predictions to establish a corrected reference for the next trend prediction. The predictions in this period were on the high side,

within 4 percent of actual labor and 5 percent of actual material indices, which are fine results. Good methodology and execution are indicated by observed correlations, which should improve as more experience is gained.

Three essential escalation outputs are produced by the Cost Analysis Branch: an estimate of total cost for each ship's budget estimate; earned escalation and a forecast of future escalation costs for each out-year for all ships under construction; and a balance sheet showing either surplus or deficit of the entire escalation account to be used in the next year's budget, as a separate line item. Brief descriptions of each output and study team comments follow.

Escalation in Budget Cost Estimates

> The analyst, by using a provided contract construction period, predicted BLS indices for material and labor, material and labor cost estimates furnished by cost estimators, and terms of the contractual clause, can obtain by computer the total amount of escalation dollars that may be expended on each ship of each proposed contract. This is included in the ship's estimate.
>
> Since ship construction history indicates that the average delay in contract delivery of ships was 7 months, a 10 percent surcharge, identified currently as a cost impact for the "1975 Clause" ("Marshall Clause") to provide

escalation to actual delivery date instead of to scheduled delivery date is applied.

In the House Subcommittee Hearings on DOD Appropriations for 1977, Part 8, Pages 219-220, 63 ships of 87 under contract, including those on which work has not yet started, are identified as being behind schedule. The average lateness of the total number of 87 ships is over 10 months; hence, the surcharge noted above may be inadequate. More importantly, a gross average like this is misleading, as lateness appears to vary by type of ships. (Some submarines are over 2 years late.) The surcharge percentage should be investigated for a more accurate basis of application, as the present "10 Percent Marshall" can cause substantial deficits in highest priced ships when lateness in delivery exceeds the assumed seven-month period. The obvious solution is to predict with more precision a realistic construction period.

Earned Escalation and a Forecast of Future Escalation Costs

For each ship under contract in an approved program the earned escalation amounts are computed quarterly in a current year by actual labor expended and BLS indices, as data becomes available. For the out-years, the latest actual BLS indices are used to adjust material and labor expenditure forecasts. By this technique the Branch produces a continuing modification to escalation accounts to achieve greater accuracy in predicting the final requirements for the ship construction contract and change orders. Ship deliveries are tracked and possible delays are included in upward adjustments of escalation costs. Also included are an add-on for increased costs of energy, and other special provisions, which may enter into contracts. The latter costs are vague, as requirements are not well defined.

The methodology is as thorough as needed for this task, but outputs are affected by irregular submittals of necessary information from shipyards. The Branch needs

monthly returns to do an optimum job, but does the job as best it can on a quarterly basis. Assistance from the Supervisor of Shipbuilding at building sites is needed occasionally to obtain necessary inputs into programs.

Escalation Balance for Each Year

Because of the rapid rise in the escalation shortfall due to inflation and its effect on ships' costs, a special accounting was ordered in 1972. Escalation deficits in the total program were requested to be funded from a separate cost growth appropriation included in the budget annually. The Cost Analysis Branch had to provide the required information to identify the current amount needed. Each annual budget now includes a separate line item for the current escalation balance. At present about 110 ships are involved in the computation of this balance.

Most current ships under construction were estimated prior to 1973, at which time the Cost Analysis Branch first applied its vastly improved techniques to forecast escalation. Returned costs for escalation come in monthly to test the accuracy of previous estimates and guide current estimates. Efficacy of the improvements made from 1973 to the present should be demonstrable within the near future on short term contracts and on forecasts of longer term contracts, and is expected to show a satisfactory correlation between estimated and actual amounts for escalation. Present methodology for required outputs is considered to be nearly optimum for the quality of inputs. Inherent deviations will always exist because of directed changes, unexpected future developments in the economy, and degree of accuracy in provided data for computations. Developed checks enable the Branch to adjust data at frequent intervals and advise all levels of management of significant trends requiring attention.

Some increase in capability of the Branch can be achieved by improved inputs, namely:

- Routine and prompt monthly cost information from shipyards.
- A more accurate forecast of delay in construction of each ship type.
- Guidance from some econometric service for predicting BLS indices, particularly on material.
- Thorough analysis of past predictions against actual results to refine assumptions in various processes where needed.

(6) Market Analysis

The Cost Analysis Branch started in 1974 to provide a guidance to estimators on future market conditions for program priceouts. It predicts the shipbuilding workload in 17 major shipyards two years in advance and indicates the most likely bidders by ship type in the program. The purpose is to guide estimators in selecting necessary rates for a budget estimate only from yards that will have the potential to undertake new work. Labor and overhead rates for those yards should result in a more accurate estimate than if they are taken for a larger group in which several yards cannot become involved. Additionally, a bidding policy for probable bidders may be predicted if their future workload can be evaluated. This would

affect the selection of profit for the estimate.

The market has a great influence on bid prices. The Branch prepared Figure D.9 for a specific case. However, it illustrates the potential effect of bidding policies for every situation. Figure D.10 illustrates for a large number of bids the variances in prices assuming competition. It indicates also what can occur if there is no competition. For example, the NAVSEA budget for what is considered to be an average bid may be off by at least 12.5 percent solely for the reason of the absence of a competitive market. Estimators therefore must consider the nature of the market especially to protect budget estimates against large increases solely for restricted conditions.

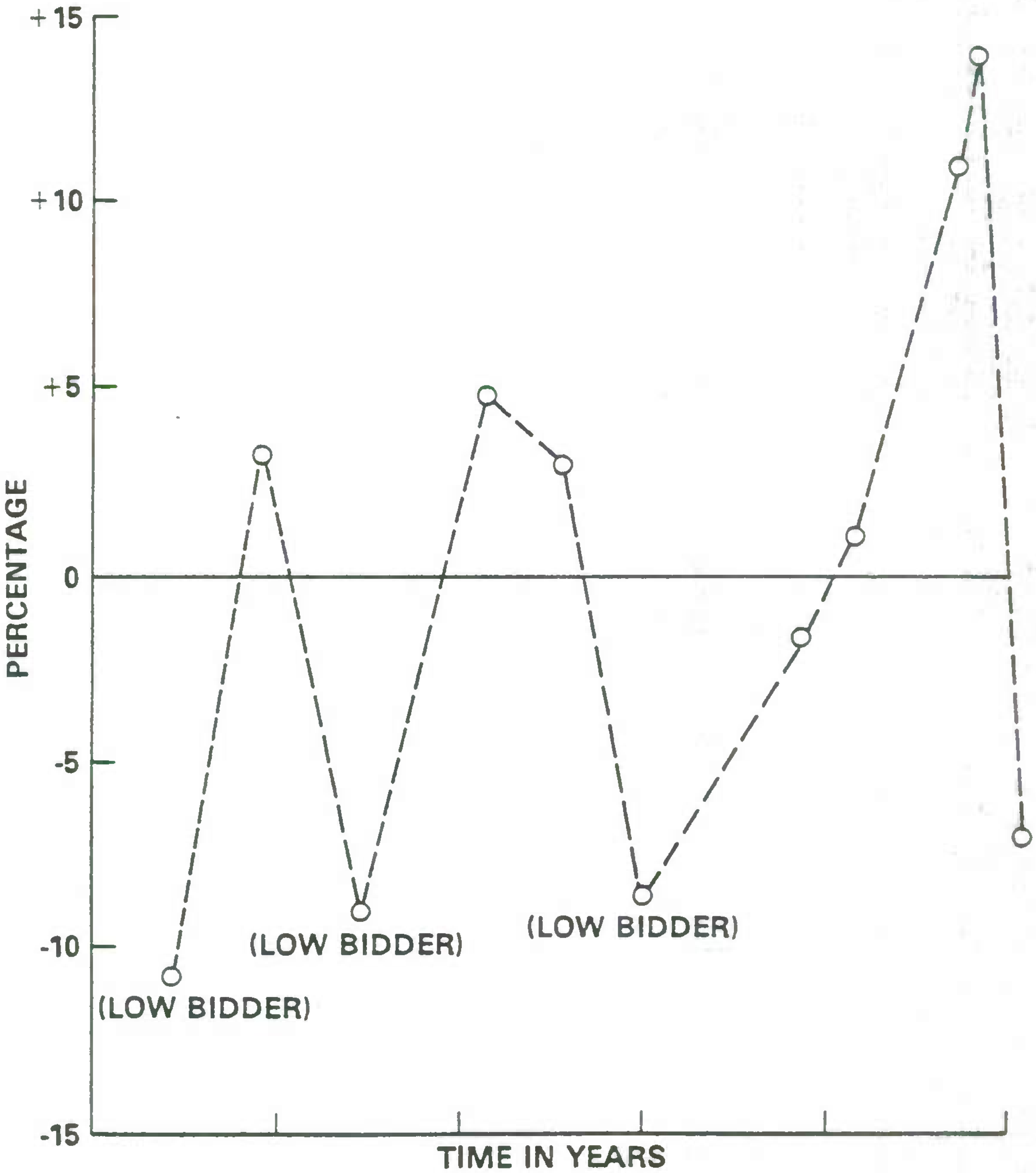
Because of the nature of naval ship complexity the most likely market for nuclear ships consists of one shipyard, for submarines two shipyards, for DD 963 class ships one shipyard,[1] and FFG 7 class ships three shipyards. This leaves ships of a less complicated nature which dollarwise are a small portion of the usual Navy budget subject to more or less a normal market.

[1] Technically this ship could be built in a number of U.S. yards but since Ingalls has these ships in series production, it is unlikely that another yard would underbid Ingalls so long as they are interested in this work.

FIGURE D.9

CHANGES IN COST ESTIMATES FOR SPECIFIC CONTRACT

(0 = BIDS)

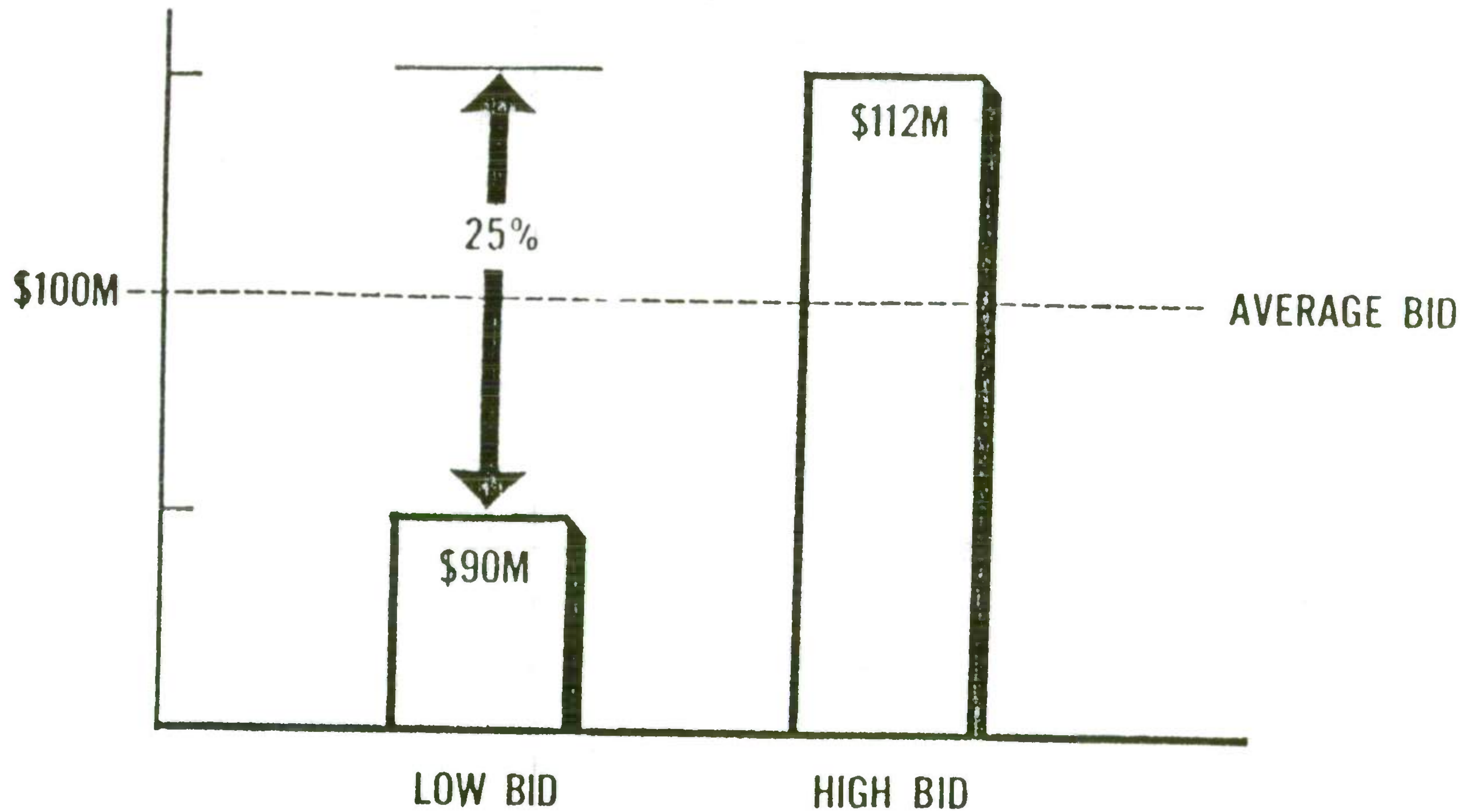


PREPARED BY
SEA 01G
OCT. 1976

FIGURE D.10

SPREAD IN SCN BID PRICES

(FY '64 THRU FY '71 FOR 206 BIDS FOR 51 COMPETITIVE SITUATIONS)



SOURCE: NAVSEA 01G

Sources for developing a workload composite are Navy's records of current shipbuilding activities, Maritime Administration's records for merchant ships under contract, and anticipated new work by both organizations. In addition to bar charts showing this information, the guidance includes an informative narrative about developments at each of the 17 yards as they relate to their ability to undertake additional work.

The workload guidance does not include commercial ships for private accounts at some major shipyards not does it include predictions on non-ship work. Current construction records could be obtained from the American Bureau of Shipping; however, it is unlikely that information on work two years hence could be predicted or obtained.

(7) Productivity Guidance

When historical cost data is used for reference in estimating labor man-hours for current ships of similar types, estimators must make adjustments for various factors with productivity being an important one. They use formal annual guidance provided by the Cost Analysis Branch since 1969. Previously, estimators used their own judgment.

Fundamentally, productivity is labor efficiency, or:

$$\frac{\text{output in units of work}}{\text{input of labor and facilities}}$$

The equation defies scientific analysis as no factor can be held firm with constantly changing conditions for numerator and demorninator. A more practical measure used by managers is to compare actual man-hours spent on a task with budgeted man-hours. This assumes that the budget is correct, which may not be the case on complex or novel ships, in an unsettled labor situation, or with changing management. Both approaches are speculative, yet the the requirement to consider productivity in estimating remains.

The following organizations made studies on this matter between 1958-1973:

- Institute for Defense Analyses
- Webb Institute
- Center for Naval Analyses
- Commission on American Shipbuilding
- Price Commission, '72

- Logistics Management Institute
- American Association of Cost Engineers

The first four studies on shipbuilding productivity were analyzed and were found to disagree and conflict with each other to such an extent that they could not be used with confidence. For example:

- One study concluded that productivity on hull steel work in America was one-half of that in Japan. Another contemporary study claimed that American productivity was 30 percent above Japan's on hull steel.
- Productivity on entire ships was found to have increased 10-15 percent from 1958-1966 in observed American shipyards. This contrasts with a finding of another study that it increased 1.4 percent per year from 1958-1969 in shipbuilding and repair. Addition of repair work, which is so variable as to be impossible to compare, makes the finding suspect, and invalidates it for shipbuilding alone.

The Cost Analysis Branch does not use any results from these studies, and relies principally on recent experience, which will be listed subsequently, to predict trends in productivity for budget estimates. The trend has been downward at all yards, except where modernized facilities were provided; however, it only leveled off at those yards for a brief period.

A DCAA report of experience at one shipyard in 1972 showed that man-hours/ton of steel work decreased by 15 percent over similar work in the 1960's. Pertinent to this lower productivity were these findings:

- Mechanics dropped from 72 percent of the force to 50 percent.
- The yard lost 58 percent of new hires that year.
- Idleness in shops increased to 29 percent from the 20 percent factor considered acceptable.

There is a scarcity of such data. Even though it is subjective in part, more of it would be useful.

Productivity is best observed by shipyards themselves. They are aware of current changes in management, technology, facilities, and work ethic; loss of skills and turnover of labor force; impact of changing safety regulations; and their returned costs on a shop basis. These are reflected in their bids for future work.

The Branch has analyzed some shipyards bids and returned costs, and obtained comparable analyses from the Maritime Administration for commercial vessels, and continues to do so, to determine the trend for a gross productivity measure. Additionally, it

considers current publications on the subject.

Its first input was in 1972 with a recommendation that an additional 10 percent be added to man-hours based on bid data prior to 1966, with a lesser adjustment in the following years. Further in-depth analysis in 1974 showed a continuation of the downward trend; hence, the instruction was to add 15 percent additional manhours to all historical bid data to reflect current labor requirements. At present, the 15 percent add-on is still in effect when no returned costs are available for a comparable vessel. This is very brief information for a growing problem on a large element of cost. It is produced by a qualified and experienced analyst, on a part-time basis, and is the best that can be developed with present data resources. Judgment of its merit is still in the future.

Possible improvements for developing guidance for productivity are:

- Train a back-up for the single analyst now making the predictions.
- Obtain comparative data from more shipyards.
- Identify all yards where special facilities play a large role in determining output, and establish trends for such yards individually, or at least as a group.

- Identify effects of management change through Supervisor of Shipbuilding.
- Track results from previous guidance to test its accuracy.

Subjective judgment plays such a large part in defining and predicting future productivity that additional measures still will not be as reliable as desired. However, more information and experience obtained from the above factors should produce greater accuracy for specific estimates and improved confidence in the overall task. It would seem appropriate at this time for the Navy to make a special effort to study what impact a larger Navy program will have on future productivity trends in shipyards which will be affected mostly by this program.

Exhibit D.2 Factors Affecting Shipyard Productivity is a special study of productivity made in conjunction with this study.

(8) Learning Curves

For accurate estimating on multiple ship contracts consideration must be given to expected decreases in material and labor on repetitive operations. Material costs in constant dollars should be less since there should be fewer errors and less waste and scrap, as

familiarity grows. In an even larger degree, labor hours should decrease also as prior production problems are solved and workers become familiar with construction plans, materials and the ship. Such decreases have been expressed historically by learning curves, which are anticipated by cost managers in Navy and OSD and must be applied by estimators in the Cost Estimating Branch.

Prior to 1969, a learning curve based on bid experiences of the Maritime Administration and Navy was used. Findings of other experts in the ship production field were considered also. With productivity slipping, as noted in a preceding section, the Cost Analysis Branch provided more judgment and relied less on the available historical curves for its guidance report.

In 1969 a management research firm completed a study of learning curves for NAVSEA. It was based on 210 bids for 29 classes of ships and resulted in one of the items now being used by the Cost Estimating Branch as a guideline.

Being based on bids, and not on returned costs, the study utilized shipyard predictions of improvement, which hopefully reflected actual experience and serious bidding intent. As these

factors were unknown the real merit of the resultant study is unknown. The curves show expected downward trends for material and labor and have been used with caution since they became available.

The Cost Analysis Branch performs a valuable function regarding this guideline in advising estimators about actual current conditions in the industry. These changed adversely shortly after the 1969 study was completed. Unexpected labor turnover and loss of skills in yards, as described in the previous section on productivity, destroyed the learning curve completely at one shipyard in 1970-1974. Another yard assumed no learning in pricing a series of large tankers started in 1973. The Branch found that in a third yard more man-hours were used on a recent small craft than were expected on an identical one several years earlier. This decline in productivity all over the country has resulted in de-emphasis of learning curve data, and a partial substitution of up-dated actual observations by the Branch. Some productivity data are obtained from the Maritime Administration on a regular basis.

Programs for multiple ship contracts which were priced out for construction in the late sixties on normal learning curves, regardless of source, can be expected to show overruns for this factor alone. One opinion was expressed within Navy that the curve will cost each of thirty DD 963 class ships in the FY 1970 program about 10 million dollars, because it assumed too rapid a decrease in successive ship costs.

The current estimating approach is to use the developed cumulative average learning curve guidance from the study on a conservative basis. (The cumulative average results in application of learning percentage decreases to the ship number which is double the previous base, i.e., starting with hull #1, compute for hulls #2, #4, #8, etc. Percentages for intermediate hulls are taken off the plotted curve of computed points.) A one percent learning reduction is used for material unless trends of inflation indicate otherwise. This is equivalent to a .99 slope of the curve. (The bid study indicated a 2.1 percent learning, or .979 slope.) A 5 percent learning reduction, or .95 slope, is used for labor man-hours, unless labor force or management patterns of prospective shipyards does not warrant this. (The bid study indicated 6.8 percent learning, or .932 slope.) Judgment of the estimator is

the key factor to avoid erroneous predictions of learning, which could grow to large numbers in dollars on a program of many ships. Their present approach is conservative obedience to expected provisions of learning benefits.

The bid analysis study of 1969 should be followed up with a similar returned cost study for the ships actually built. It would test the learning curve theory for applicability, identify departures, and provide guidance for future use on a more accurate basis. One expected disclosure is that learning curves can reverse their trends toward ends of contracts. Materials borrowed from last ships to replace broken, lost, or malfunctioning items on previous ships must be re-purchased. Unless future work is assured, labor man-hours on last ships can exceed totals experienced on immediately previous ships. These reversals were observed in merchant ship construction, and it may also be true on Naval work.

An unexplored aspect in learning curve and productivity considerations is management effectiveness. This could be a large factor. The Ship Production Office, SEA-075, can establish a management rating baseline for each shipyard when it surveys it as a pre-contract award requirement. The Supervisor of Ship-

building can periodically advise on principal changes in management to alert all interested parties about possible future effect on performance of the work force. This would become another input for the Cost Analysis Branch to use in its guidance to estimators.

(9) Profit

The first issue of the present form of formal guidance for profit in budget estimates was prepared by the Cost Analysis Branch in 1973 and has been continued annually. Before 1971, it was policy to budget 10 percent of cost for profit. As a result of Armed Services Procurement Regulations (ASPR) of 1970, the Cost Analysis Branch developed a schedule of profit rate determination for use of cost estimators. It consists of provisions for risk, level of performance, and development of facilities; instructions for types of contracts; adjustment for return on investment and a summary table of all factors and percentage ranges for computation of a profit rate to comply with ASPR.

Estimators must budget 10 percent as a minimum profit on all estimates. The maximum can exceed 15 percent if upper limits of component allowance ranges are considered applicable.

To augment this guidance, the Branch tracks profit quotations in recent bids and in contracts reached by negotiations. An evaluation of market conditions as they may affect profit quotes in future bids is also made.

This guidance is considered to be adequate for the purpose and should result in profit computations having a minimum of variance from finally negotiated profit percentages.

A change in profit applications may result from a study, "Profit '76," which is being processed for inclusion in ASPR. Weight factors for basic elements are being changed. Also, profit on escalation may be applied, which is not the practice now. Profit on escalation has been applied to the FY 79 budget estimates and allowances have been added for facilities.

4. MANY IMPROVEMENTS HAVE BEEN MADE IN SEA 01G IN THE PAST TEN YEARS

As discussed elsewhere in the report, many studies have been made of NAVSEA's ship acquisition and cost estimating. Partly as a result of the recommendations attendant to these studies and the realization that the Cost Estimating and Cost Analysis Function needed strengthening, several major improvements have been made.

(1) Professional Staffing Increased 140 Percent Between 1969 And 1972

In 1969, the Cost Estimating Function in NAVSEA, now SEA 01G, numbered ten. By 1972 this number had been raised to 24. At this writing, professional staff now stands at 21.[1] The 1969 SCN Study led to the creation of a Cost Analysis Branch which now has 10 professionals. This is where most of the growth has taken place. The estimating branch grew from 10 to 14 during this time.

An increase of three resulted in 1974 when the three NAVORD estimators were combined with the ship estimators to

[1] Excludes clerical and trainees

become NAVSEA 01G. The NMARC study which was completed in January 1975 recommended additional staffing for the NAVSEA 01G cost estimating function. However, the only staff increase was the direct result of the Assistant Secretary of the Navy transferring three billets from NAVCOMPT to NAVSEA 01G. The overall gain in the estimating staff has therefore been one.

(2) Additional Staff Has Made It Possible To Make A More Systematic Appraisal Of Economic Factors That Have Great Impact On Cost Estimates

The new Cost Analysis Branch has relieved the estimators of some of these cost analysis responsibilities and now reviews and analyzes economic data in a more regular and consistent manner. This is covered in detail elsewhere in the study. To summarize, the Cost Analysis Branch studies the following on a regular basis:

- Inflation guidance to estimators
- Labor cost guidance to estimators
- Contract escalation projections
- Productivity
- Overhead guidance to estimators
- Staff participation in proposal Technical Analysis Reviews (TAR)

- Cost modeling for parametric estimating given CER's

(3) SEA 01G Was Instrumental In Formulating OPNAV INST 7720.2 To Establish A Cost Estimate Ranking System

This instruction sets up the following classification of estimates..

- A. Detailed Cost Estimate (Post Budget-Contract Estimates) - estimate based on contract plans and evaluation of firm quotations for major material items.

- B. Bid Evaluation Cost Estimate (Post Budget - Contract Estimates) - estimates based on contract plans and evaluation of contractor proposals in response to an RFP.

- C. Budget Quality Estimate - estimate based on an engineering analysis of detailed characteristics of items under consideration.

- D. Feasibility Estimate - estimate based on technical feasibility studies and/or extrapolated from higher quality estimates of similar items.

- E. Computer Estimate - estimate developed usually by a computer model and based on cost estimating relationships and gross parameters.

- F. Ball Park Estimate - quick cost estimates prepared in absence of minimum design and cost information and based on gross parameters.

- X. Directed or Modified Cost Estimate - estimate not developed by SYSCOMS through normal cost estimating processes.

(4) <u>SEA 01G Has Initiated A Comprehensive Training Plan For Their Personnel That Promises To Be Effective If Fully Implemented</u>

In 1971 SEA 01G initiated a long-range training plan designed to give each of the Cost Estimating/Cost Analysis staff training tailored to their individual needs. The substance of the training program is described as follows:

- Thru a thorough examination of all Cost Estimating and Cost Analysis positions, the succinct skills and knowledges necessary for the employee to efficiently produce the cost estimates, cost studies, analysis, escalation projections, budgeting data, etc., were determined. These identified skill/knowledge requirements were then weighted to reflect the degree of importance to individual positions.

- Each employee was interviewed to determine the extent he has acquired the skill/knowledge requirements identified for his position thru formal training or practical experiences.

- A schedule of training on a yearly basis was then established which emphasized that training most needed to attain the skill/knowledge requirements for each position.

- Since training in the truest sense is not restricted to formal classroom instruction, but rather the learning process to be qualified or proficient, job related training was developed and expanded to include:

- Inter-Command weapon system presentation
- On-the-job training
- Job rotation
- Workshops
- Seminars
- Selected readings
- On-site orientations

. Allocated training based on highest priority and resources availability.

. Require the preparation of a training critique form upon completing training assignments which is used to evaluate the training as related to the cost estimating and cost analysis tasks.

. Plan flexibility allows supervisor selection of training to satisfy individual needs, i.e. reading assignments, short courses, state-of-art training or long term formal education. Its format provides for new training listings, schedule changes, etc., without a major overhaul of the volumes. Many features make the plan self-sustaining including the firm skill/knowledge requirements for each position.

. Operate and maintain a library of job related periodicals, studies, reports, texts, etc., for ready reference.

The implementation of this plan has been rather modest according to the records kept thus far.

Calendar Year	Average Cost Per Employee	Average Training Hours Per Employee
1971	$149	52
1972	34	22
1973	79	28
1974	52	15
1975	74	33
1976	88	65
1977	72	95*

*Estimated

(5) These Improvements Though Substantial Were From "Ground Zero" And Much Remains To Be Done

It is quite apparent from the numerous studies made in the past and in the findings in this study that the improvements in these areas were needed and still more should be done to provide the Navy with a first class cost estimating and analysis operation.

5. A SPECIAL STUDY SHOWS OVERHEAD GROWING AT A RATE 40 PERCENT GREATER THAN DIRECT LABOR

The purpose of this IMA-commissioned study (Exhibit D.1) was to identify cost drivers in overhead, to predict the course they may take and to demonstrate how the Navy may adequately estimate shipyard overhead. The scope of the study was limited to one major shipyard doing Navy work during the period of 1969-1975. Most data were retrieved from DCAA records.

(1) The Study Indicates Rapid Overhead Growth

The key observations of the study regarding overhead costs are as follows:

- Change orders grew by 5.5 percent, but length of construction by 44 percent.

- Labor man-hours grew by 19 percent, but labor costs grew by 53 percent.

- The most startling growth (among all factors) was 74 percent in overhead, or at a compound growth rate of 11.8 percent per year.

To investigate this large overhead growth, nine overhead sub-accounts were grouped into three major categories for ease of analysis. The following findings summarize principal developments relative to the three categories:

- "Human-related variable costs" grew by 11.53 percent per year. These consisted of fringes and benefits, indirect labor, etc. Changes mandated by legislation accounted for 23 percent of the total rise.

- "Semi-variable costs" grew by 23.40 percent per year. Energy costs, home office expense, etc., are included in this category.

- "Fixed" costs grew by 6.5 percent per year, for depreciation, taxes, and similar expenses.

Beyond the three categories, these general observations can be made:

- Overall overhead expressed as a percentage of direct labor, increased by 21.4 percent for the shipyard. Human-related factors accounted for 71 percent of this rise and semi-variable factors for 28 percent, with only one percent by fixed costs. Only one-third of those increases was considered controllable by the shipyard, with the major portion driven by external pressures. The projection for each of the nine sub-accounts is given on Table D.8. Growth of the human-related factors by 1980 is expected to be at a lower rate, whereas growth of other factors should be at a higher rate.

- Effect of delay in construction on overhead rate varies with management. A well-managed stretch-out to preserve labor efficiency and control indirect labor can limit growth of overhead to 20 percent, while a questionably managed stretch-out may cause a growth of 65 percent. The basis of these conclusions and the consequences on a ship's cost are shown on Table D.9.

(2) Overhead Estimating And Forecasting In NAVSEA Needs To Be Reorganized

The present NAVSEA procedure used to estimate and review overhead for a project is shared by several organizational entities and requires three to twelve months to complete. Except for budget estimates, including overhead, which SEA 01G makes, the contracting officers have the principal burden of negotiating overhead rates via DCAA.

The Technical Analysis Review Procedure (TAR), as presently

TABLE D.8

STEADY STATE MODEL COMPOSITION OF OVERHEAD
(percent)

	1969	1975	1980 (Guesstimate)
Human Related "Variables"			
Indirect Labor	30.9	22.5	21.3
Indirect Repair and IR&D, Bid and Proposals, Tools	5.6	9.2	10.5
Fringes and Benefits	38.9	42.5	40.0
SubTotal	75.4	74.2	71.8
"Semi-Variable" Costs			
Maintenance and repair material	3.1	2.0	1.9
Energy Costs	3.3	5.4	6.0
Information Processing/ Home Office Expense	0.5	5.0	5.7
SubTotal	6.9	12.4	13.6
"Fixed" Costs			
Depreciation and others	7.0	4.0	3.1
Fixed Repairs	2.0	1.9	1.8
General Overhead	8.7	7.5	9.7
SubTotal	17.7	13.4	14.6
TOTAL	100%	100%	100%

TABLE D.9

EFFECT OF DELAY ON OVERHEAD RATE
(Dollars in Millions)

		Budget		Example 1 "Well Managed" Stretch-out		Example 2 "Questionably Managed" Stretch-out		Example 3 Example 2 Adjusted For 10% Escalation
Material		50		50		50		61
Direct Labor		50		50		55		67
Overhead:								
Variable	30		30		60		73	
Fixed	10	40	20	50	20	80	24	97
Total Cost		140		150		185		225
Fixed Fee		14		14		14		14
Price to U.S.Navy		154		164		199		239
Overhead Rate		80%		100%		145%		145%

Assumptions:

This project is 100 percent of yard capacity.
Time stretchouts assumed to be to twice the schedule (schedule = 2 years).

Example 1:

Stretch-out due to external forces, no increase in material or direct labor. Prompt management response to stretchout preserves direct labor efficiency and reduces variable overhead in a timely manner.

Example 2:

Stretch-out due to external forces, no increase in material. Direct labor efficiency drops by 10 percent due to slow management reaction to stretch-out; overhead not curtailed during stretch-out.

executed, is an evaluation of the reasonableness of a low bidder's estimate and delivery schedule. This review is not necessarily proof that the prospective contractor is productive and well-managed nor that its costs, including overhead, reflect acceptable effectiveness. No independent estimate is made to determine if the Navy is getting reasonable predicted value on fixed price incentive and cost type contracts, unless one is considered necessary.

(3) Greater Attention To Overhead Estimates Is Needed

In SEA 01G, one person spends about 40 percent of his time preparing overhead cost projections for all shipyards. The data bank is limited compared with what could be considered optimum, i.e., data with detail based on ten to twelve summary accounts as it is available via DCAA for each shipyard.

The size of overhead costs and number of shipyards involved in Navy contracts indicate that greater emphasis on this factor is required. It should be provided by a group of professionals skilled in engineering, business management, and shipbuilding with resources to spend one-third of its time in the field where the information is in the proper form and quantity.

(4) Other Findings Offer Potential For Overhead Savings To The Navy

The study has developed certain findings that would seem to aid in providing better performance in overhead management.

- Closer monitoring of contractors' management by qualified personnel could influence performance on cost and incentive fee contracts.
- Overhead analysis should be carried out using specific detailed costs, as outlined in the report, instead of percentages.
- It would be advantageous for SEA 01G to establish better communications with PMS, SUPSHIPS, and DCAA units.

It must be recognized that this phase of the study was of limited duration and involved examination of overhead costs from but one shipyard. Thus, while of sufficient depth to model the various elements of overhead with respect to their variability and sensitivity, the data should not be used as a basis to forecast future trends in overhead costs without analysis of a broader data base from other shipyards.

6. SHIPYARDS CONSIDER PROGRAM STABILITY TO BE ESSENTIAL TO INCREASING PRODUCTIVITY

The purpose of this IMA-commissioned study (Exhibit D.2) was to obtain from the shipbuilding industry an identification and evaluation of factors which

affect productivity, and to present data which would show their effect upon Navy ship estimates.

Fourteen organizations were surveyed, i.e., major U.S. shipyards, naval architects, industry and government agencies, and most agreed on the general nature of productivity factors, but considered accurate estimates of their effects difficult or impossible in most cases. To the degree that it was possible, the study developed a range of quantitative effects and these are presented in summary form in this section.

Productivity can be measured by various parameters. There are six methods for applying input data and five methods for measuring output, thereby offering many combinations for obtaining a result. Selection of the method will naturally affect the conclusion. For this study, the manhour input and physical output combination was selected.

Table D.10 shows the relevance of 19 productivity factors, numbers 1-13g in the heading, on 31 variables in shipyard operations. Each variable is discussed in the referenced SNAME paper #10 given in November 1976 to indicate its impact on shipbuilding costs. They are grouped on the Table into three classes for a summary of impact, which is:

- Class I variables, as a group, can potentially increase an estimate by ten percent.

TABLE D.10

INTERRELATION OF FACTORS & ESTIMATING CONSIDERATIONS

VARIABLES
SNAME PAPER #10 - 1976

The Variables below are grouped by the magnitude of their effect on shipbuilding costs.

	Factors Considered in This Study																		
	1	2	3	4	5	6	7	8	9	10	11	12	13a	13b	13c	13d	13e	13f	13g
	Stability of Operation	Labor Availability and Turnover	Automation and Mechanization	Shipyard Engineering Capability	Learning Series Construction	Social Legislation	Training Programs	Labor Agreements	Increased Complexity (All Ships)	Shipbuilding Market	Inflation	Other Economic Trends	Contract Administration	Changes Under The Contract	Inspection And Plan Approval	Quality Control	GFM & GFI	Delays	Complexity (Navy Ships)
Class 1																			
Other Work In Yard	X	X									X								
Manpower Levels	X	X	X		X	X	X	X	X					X	X			X	X
Escalation								X			X			X			X	X	
Status of Design				X					X					X	X		X	X	X
Class 2																			
Efficiency of 1st Ship					X														
Learning	X	X			X														
Material Support				X													X	X	
Pre-Outfitting				X					X					X	X		X		X
Overtime		X						X						X	X				
Facility Start Up			X																
Detailed Planning	X		X	X					X								X		
Follow-On Business	X	X								X		X		X					
Class 3																			
Design Agent				X					X					X	X				
Technical Creep				X										X	X				
Specification Enforcement													X		X	X			
Supervision & Support	X	X					X		X										
Direct/Indirect	X	X											X						
Strikes	X	X										X						X	
Catastrophes																		X	
Facility Shortcomings			X															X	
Tooling			X		X														
Process Improvements	X				X														
Make/Buy		X						X			X	X							
Vendor Negotiations									X			X					X		
Sole Source Procurement									X				X		X				X
Vendor Failures									X			X							X
Bulk Buys				X															
Loss & Scrap												X			X				
Special Wage Rates								X											
Government Regulations	X	X				X			X	X									
Fixed/Variable Overhead								X					X	X				X	
								X					X	X				X	

- Class 2 variables can increase it 5-10 percent.
- Class 3 variables can increase it up to five percent.

The majority of variables are influenced by many of the productivity factors as noted by "X" in the table. This interrelation of effects makes quantitative determinations for each variable difficult.

There was close agreement among the participants in the survey on the order of importance of several factors: namely,

Stability combined with labor availability and turnover	1st
Navy considerations	2nd
Learning (Series production)	3rd
Social legislation and training	4th
Labor agreements	5th

Considerable importance was attached to other factors by some of the participants, but there was no clear majority opinion in these cases.

(1) A Quantitative Evaluation Of Productivity Factors, Although Difficult, Has Been Attempted

The assignment of quantitative values to productivity factors is difficult for two reasons:

- It is not possible to predict the occurrence and timing, magnitude and duration for many of the factors.

- Factors represent operating conditions rather than estimating units or variables. They are interrelated, they overlap and each affects or is affected by a number of estimating variables.

It is believed possible, however, to assign ranges of magnitude to many of the factors and to make judgmental adjustments on other factors to arrive at a reasonable conclusion as to the direction and amount of an overall productivity factor. These considerations are:

- Stability -- Lack of a stable work program primarily affects labor hours. One estimate is that it would reduce productivity by as much as 35 percent. This is also related to labor availability and turnover.

- Labor Availability/Turnover -- Due to accession of untrained employees, productivity may be 50 percent of the norm for established employees over at least one year, depending upon craft.

- Automation and Mechanization -- Initial effects on productivity are adverse because of start-up problems. Subsequently, savings are produced, but in a relatively small part of the operation, particularly on naval ships.

- Engineering Capability -- A lack of such capability may cause losses of manhour productivity between 5-15 percent.

- Social Legislation -- Some effects can be anticipated. Others, such as OSHA, EEO, and EPA have to be considered individually. In the case of employee expansion, losses of 5-10 percent in productivity appear possible.

- Training Programs -- Losses of about five percent in productivity of the existing workforce may occur because of the need for additional supervision and interference of on-the-job trainees.

- Labor Agreements -- The resulting cost increases can be readily estimated.

- Increased Complexity of Ships -- Some losses in productivity, probably up to five percent, will almost certainly occur and could extend to 15 percent if major and complex design features, other than weapons, are included in a new ship. Loss of productivity for complexity of weapons cannot be evaluated for the possible variations in this factor, but the work involved in their installation cannot be performed at levels of productivity on similar work for other systems.

- Shipbuilding Market -- Fluctuations will be reflected in "Loss of Stability" and, in addition, changes of five to ten percent in price levels can occur with major market changes.

- Inflation -- This cannot be limited entirely to the projections of an escalation index, because this does not cover all cost increases. Therefore, they must be considered separately in shipyard pricing.

- General Economic Trends -- These must be considered in making forecasts for almost all the items discussed in the foregoing. The shipbuilding industry does not normally follow the general economic pattern.

- Special Navy Considerations -- Contract administration, inspection, plan approval, quality control, GFM and GFI (if working well) will require one to three percent of the total yard force. If they are not working well, it will be initially reflected in delays, and cause losses of labor hour productivity of five to ten percent. Change orders almost always cause lower productivity, even apart from possible delays.

Factors that cannot be evaluated quantitatively, but must be considered, require a judgmental projection based on recent experience. It is also important that in assigning values to various factors, the present position of each prospective shipyard is considered.

(2) The General Trend Is Toward A Drop In Productivity Over The Last Five Years

One productivity trend indicator is available for merchant ship construction. It is based on compensated gross registered tonnage and shows improvement in productivity up to 1970 and a drop of almost 17 percent for the 1971-1975 period. On naval ships, the decline in productivity was probably greater because of their complexity.

An unpublished BLS series is measured in dollar output per man-hour for all shipbuilding and repair. It also shows an improvement in productivity to 1970, but data for 1971 and later is not sufficient for a projection.

* * * * *

The survey showed that the factors believed to have major effects on shipyard productivity in order of importance are: stability of operations and workforce, special Navy considerations, improve-

ment by series production, social legislation and training, and labor agreements. There was no general consensus on the relative importance of the other factors.

Only a limited number of quantitative evaluations are available from the survey. It is concluded, however, that manhours may be doubled and cost increased by half over previous performance if all factors have their greatest unfavorable effects.

All factors are of such importance that they should be evaluated quantitatively when possible. Factors should be further evaluated, by judgment, for the probable effects where only a qualitative approach is possible. This should be done separately for different programs and each shipyard.

7. THE DEFENSE CONTRACT AUDIT AGENCY (DCAA) COULD BE AN IMPORTANT SOURCE OF COST DATA FOR THE NAVY

The DCAA was established in 1965 to provide a centralized contract auditing service for the Department of Defense. The purpose of contract auditing is to assist in achieving the objective of prudent contracting by providing those responsible for procurement and contract administration with financial information and advice on proposed or existing contracts and contractors. Audit services of the Defense Contract Audit Agency are utilized

by procurement and contract administration activities in connection with the negotiation, administration, and settlement of contract payments or prices which are based on cost, or on cost analysis.

(1) <u>The DCAA Has Wide Ranging Responsibilities And A Large And Widely Dispersed Staff</u>

The responsibilities of the DCAA are set forth as follows by DOD INST. 5105.36:

> "Performing all necessary contract audit for the Department of Defense and providing accounting and financial advisory services regarding contracts and subcontracts to all Department of Defense components responsible for procurement and contract administration. These services will be provided in connection with negotiation, administration, and settlement of contracts and subcontracts."

DCAA operates independent of control by the Services (i.e., Army, Navy and Air Force), is self funded, has 2800 employees and 300 offices broken down into six geographic regions.

DCAA answers directly to the SECDEF by receiving supervision from Asst. Secretary of Defense (Compt). They operate through the six regional managers. The shipbuilding function operates out of the SupShip Offices. This field support gives assistance to the Contracting Officer and the Contract Administrator.

Figure D.11 is a simplified diagram which shows the DCAA position in the DOD hierarchy. Policy supervision for DCAA flows from Assistant Secretary of Defense (Comptroller).

Figure D.12 is the basic organization of DCAA. The bulk of the work is done by the staff of the six Regional Managers. To facilitate Navy audits the Regional Managers have offices in the SUPSHIPS offices, or at least in close proximity to these offices and the shipyards.

(2) <u>The DCAA Provide Services To The Navy At Three Stages Of Procurement</u>

The DCAA must audit, examine and/or review contractors' and subcontractors' accounts, records, documents, and other evidence; systems of internal control; accounting, costing, and general business practices and procedures. In carrying out these functions, DCAA provides a valuable service to the Navy in the following areas.

- Pre-Award -- during this period, while the contractor's proposal is under review, the DCAA will:
  - Check actual overhead rates used in the past and check reasonable future projections
  - Check labor rates -- union agreement
  - Check labor hours -- they will check the contractor projection

FIGURE D.11

DEPARTMENT OF DEFENSE

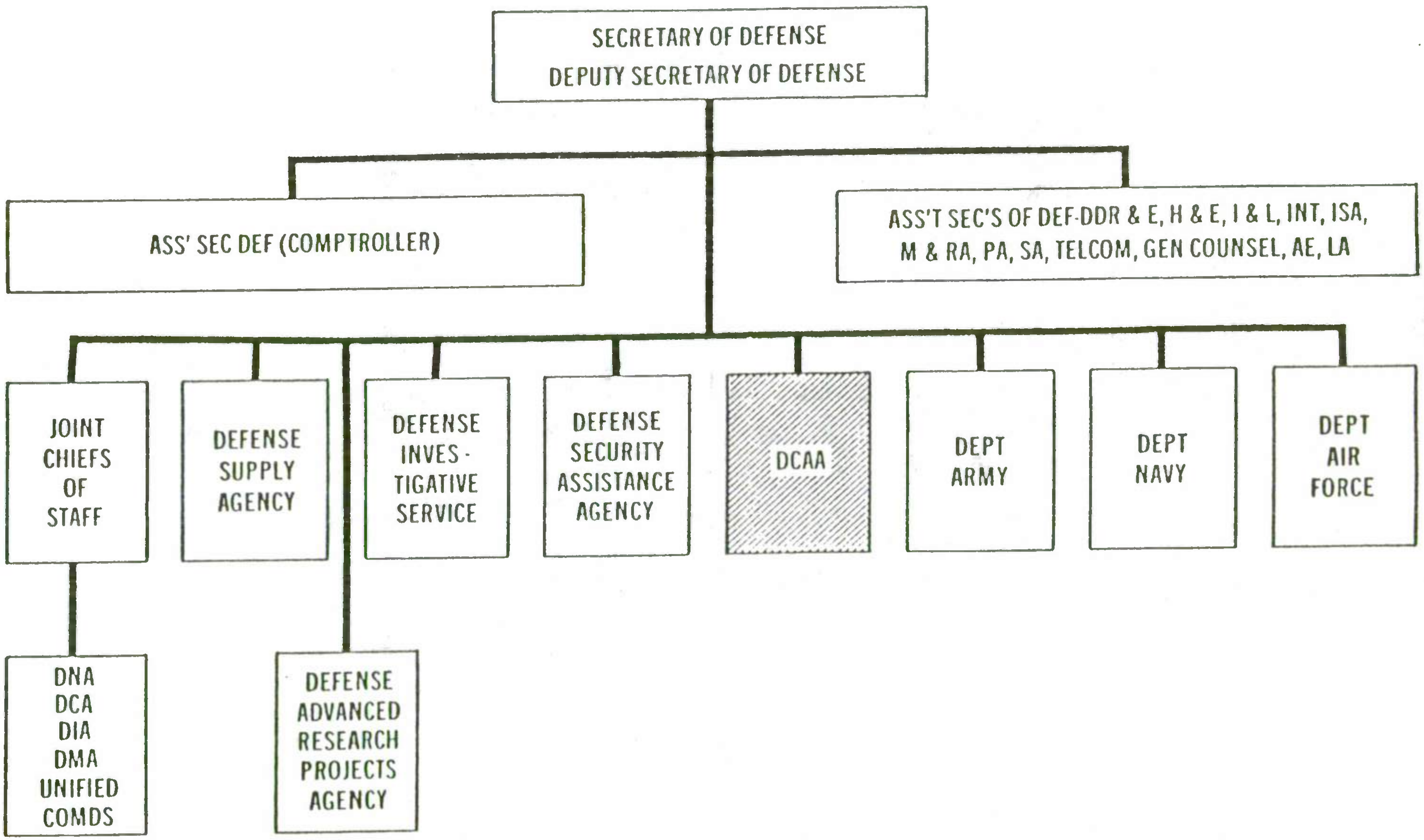
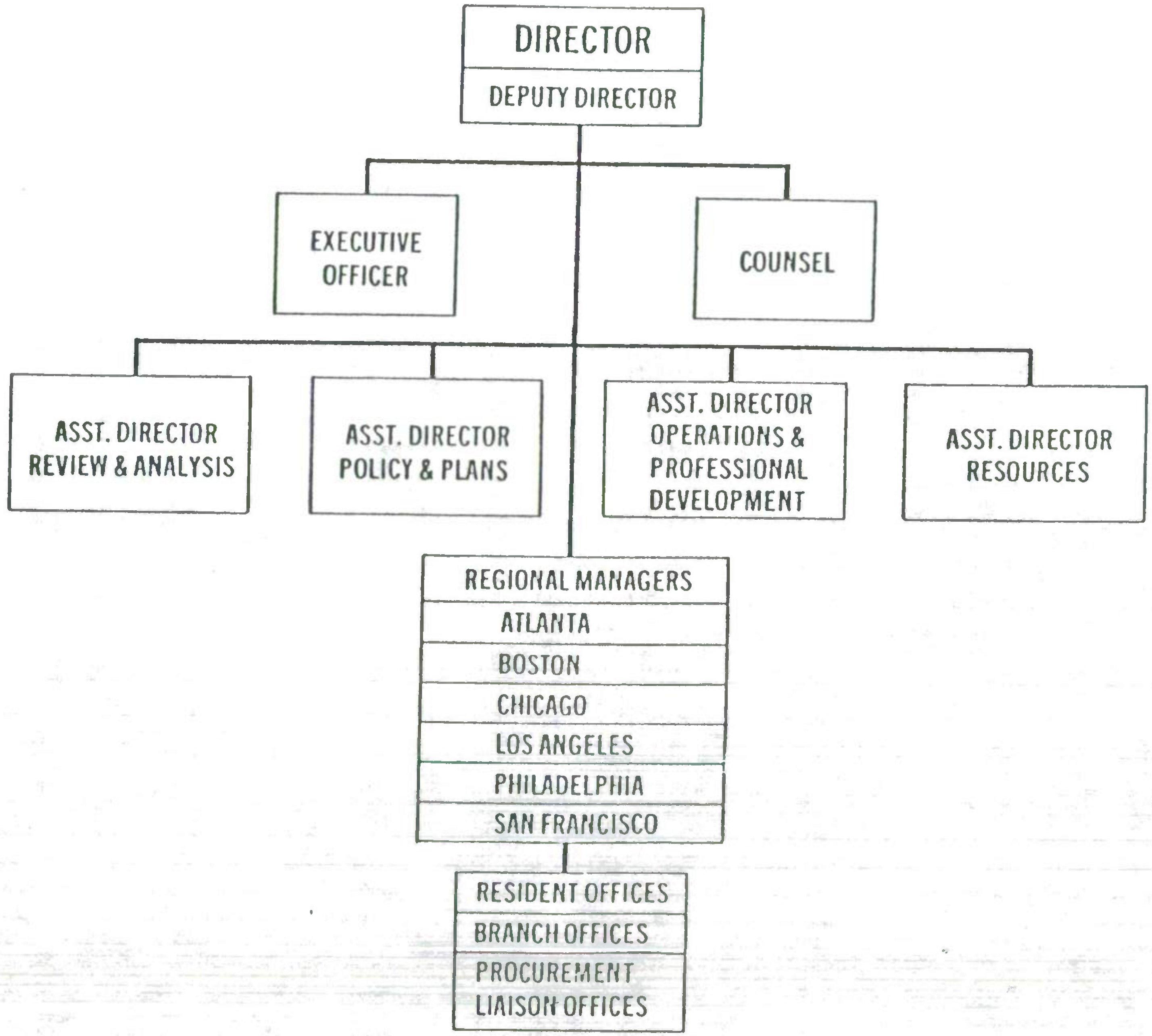


FIGURE D.12

DEFENSE CONTRACT AUDIT AGENCY



- Check material price quotations with quantity requirements verified by Navy

- Check profit assumptions

. Contract Period -- DCAA makes periodic audits of all costs incurred that cover the entire spectrum of considerations. This is required on all CPFF and FPI contracts. Checks progress payment system -- not cash payment.

. Post Contract -- final audit required to determine final fee (profit) and where claims are included to validate actual costs.

(3) <u>DCAA Could Be Of Greater Assistance To The Navy By Providing Return Cost Information If Requested To Do So</u>

Although DCAA audits are usually in the form of reports by exception, i.e., matters they feel could be improved or are out of order, DCAA would consider providing and evaluating return cost data in a prescribed manner for SEA 01G for their use in future estimating if requested. DCAA advised that as a matter of course, the Air Force uses DCAA audit findings in a data bank used to make the Independent Cost Estimates.

DCAA makes a continual Operational (OP) Audit of defense contractors and recommends to the shipyard what they believe would be operational improvements. These are discussed with the shipyard for desirability and feasibility. A "Should Cost" review, on the other

hand, should build upon the OP Audit and is aimed at reducing the cost on a specific contract.

Another area where DCAA assists the Navy is the verification of the methods used in handling scrap and salvagables including checks for excess material usage.

(4) Conclusion

Although the Navy material procurement and contract administration process is subject to DCAA audits and the Navy avails itself of its services, the cost information available in DCAA is not used to any appreciable extent by the ship cost estimators.

IV THE QUALITY OF SHIP COST ESTIMATES IS A FUNCTION OF ESTIMATING STAFF COMPETENCE, PRODUCT DEFINITION AND CERTAINTY OF CONSTRUCTION PERIOD

The ingredients needed to accurately estimate the cost of Navy ships may be placed into three broad groups, i.e., the qualifications and competency of the estimating staff, a detailed description of the end product and precise knowledge of the time frame in which the product is to be manufactured. These requirements are discussed in this chapter. They include findings from data uncovered in interviews with appropriate personnel and from written records.

1. THE PERFORMANCE OF THE COST ESTIMATE AND ANALYSIS DIVISION HAS BEEN MEASURED BY EVALUATION OF THEIR ORGANIZATION, CAPABILITY AND SUCCESS IN PREDICTING COSTS

To determine the capability of the Cost Analysis and Cost Estimating Division (SEA 01G) to make shipbuilding estimates, interview and rating forms were developed and used in interviews with twenty-three presently employed professional personnel. In the ten year period studied, 1966-1976, there were twenty other professionals employed in the division at various times. Interviews were conducted with five former employees and ratings were developed for eleven others through personnel records, thereby covering 91% of the total roster.

Desk interviews of up to two hours duration were held with each of the current staff. These were followed by numerous discussions held over a three month period with key personnel in order that their responsibilities, operations and problems could be thoroughly identified. The results are reported elsewhere in this report. Although some capabilities and weaknesses were also noted at previous points, they were not summarized, which is the purpose of this section of the report.

In addition to the interviews, samples of estimates, guidances, data banks, references and other elements that constitute the working environment within SEA 01G were examined.

Interviews were held also with several SHAPMs and contract negotiators within NAVSEA, and with some staff of OP 96D in the CNO's office. General information obtained is included elsewhere in this report. The extent that their work and comments impinge on SEA 01G will be noted in this section. Other pertinent factors from these sources will be covered later in assessments of Navy's overall estimating capability.

Visits were made to estimating departments of three major shipyards and their practices were reviewed. Detailed reports also are included elsewhere; but findings relating to SEA 01G are noted in this section.

Result of the desk audit were assembled and are presented here in graph or summary form for as much of the 1966-1976 period as it was possible to obtain. These illustrations give a general description of capability trends and factors affecting them.

(1) <u>Experience And Grade Level In SEA 01G Are On A Downward Trend</u>

Figure D.13 shows that the trend of average capability (education and experience factors) has been falling since 1974. This is attributable to the departure of several experienced personnel, all GS 13-15, and the influx of recent college graduates or people with less experience to replace them at lower grades. Exhibit D.3 describes the method used to determine a capability index. Table D.11 shows the large and adverse change in experience of personnel in recent years. Since Navy personnel policies calling for a reduction of the average grade level are to be in effect until 1981, a reversal of the trend cannot be expected. This policy also limits the Navy's ability to hire experienced people.

A comparison graph, Figure D.14, shows a relative measure of total capabiliy in the Division. As the number of personnel increases, principally because of the addition of the Combat Systems Estimating Section in 1974, the total capability increased accordingly. However,

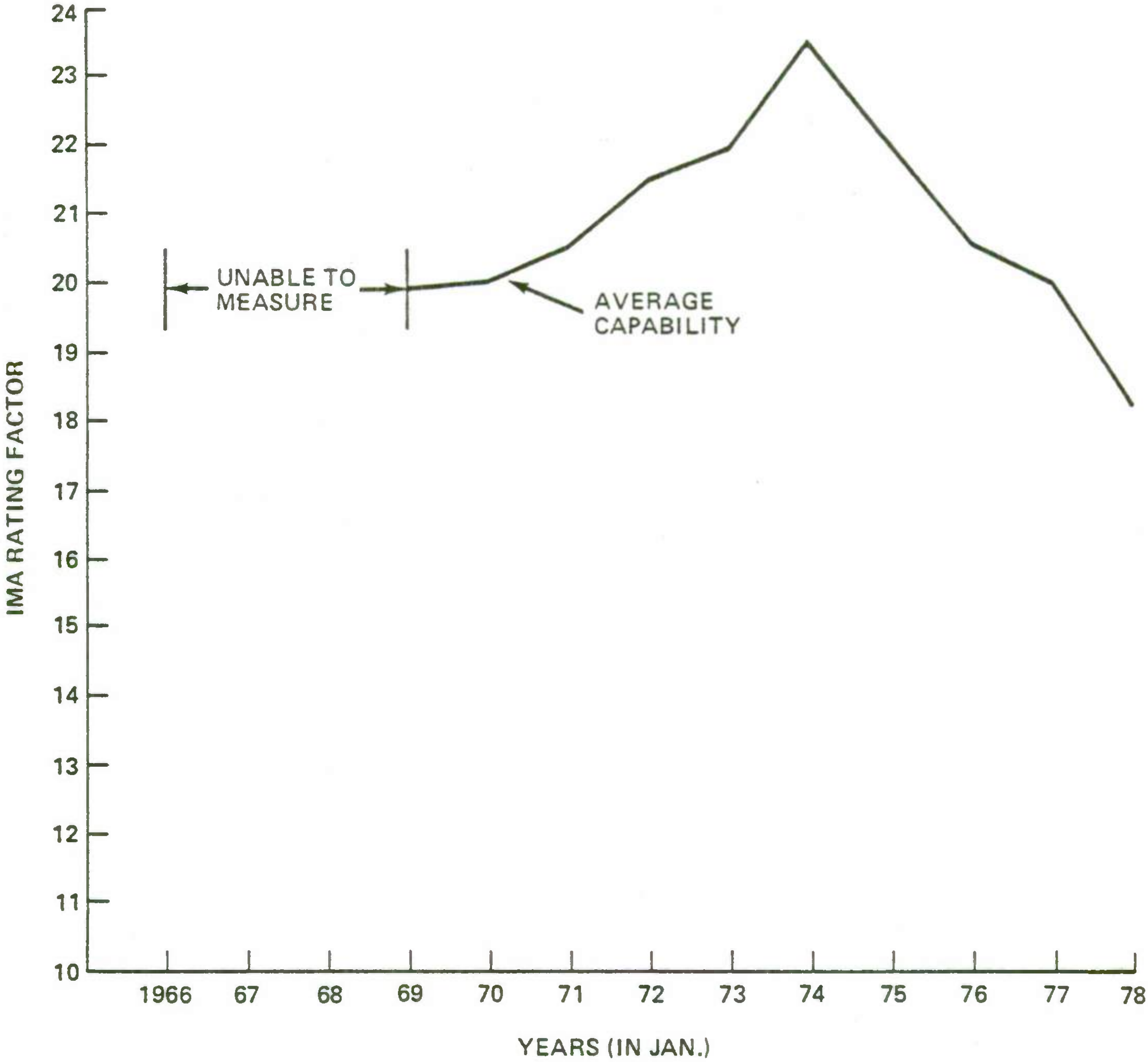
TABLE D.11

COST ESTIMATING & ANALYSIS DIVISION, SEA 01G
Years of Experience in the Division of Professionals as of Dec. 1976

Number of Years	Persons in 1976	Persons in 1975	Persons in 1974	Persons in 1973
1	6	4	3	0
2	5	3	0	0
3	3	0	0	3
4	0	0	2	3
5	0	2	3	5
6	1	3	5	4
7	2	2	4	1
8	2	4	0	1
9 or over	4	1	1	1
Totals	23	19	18	18
3 years or less	61%	37%	17%	17%
Over 5 years	39%	53%	56%	39%

FIGURE D.13

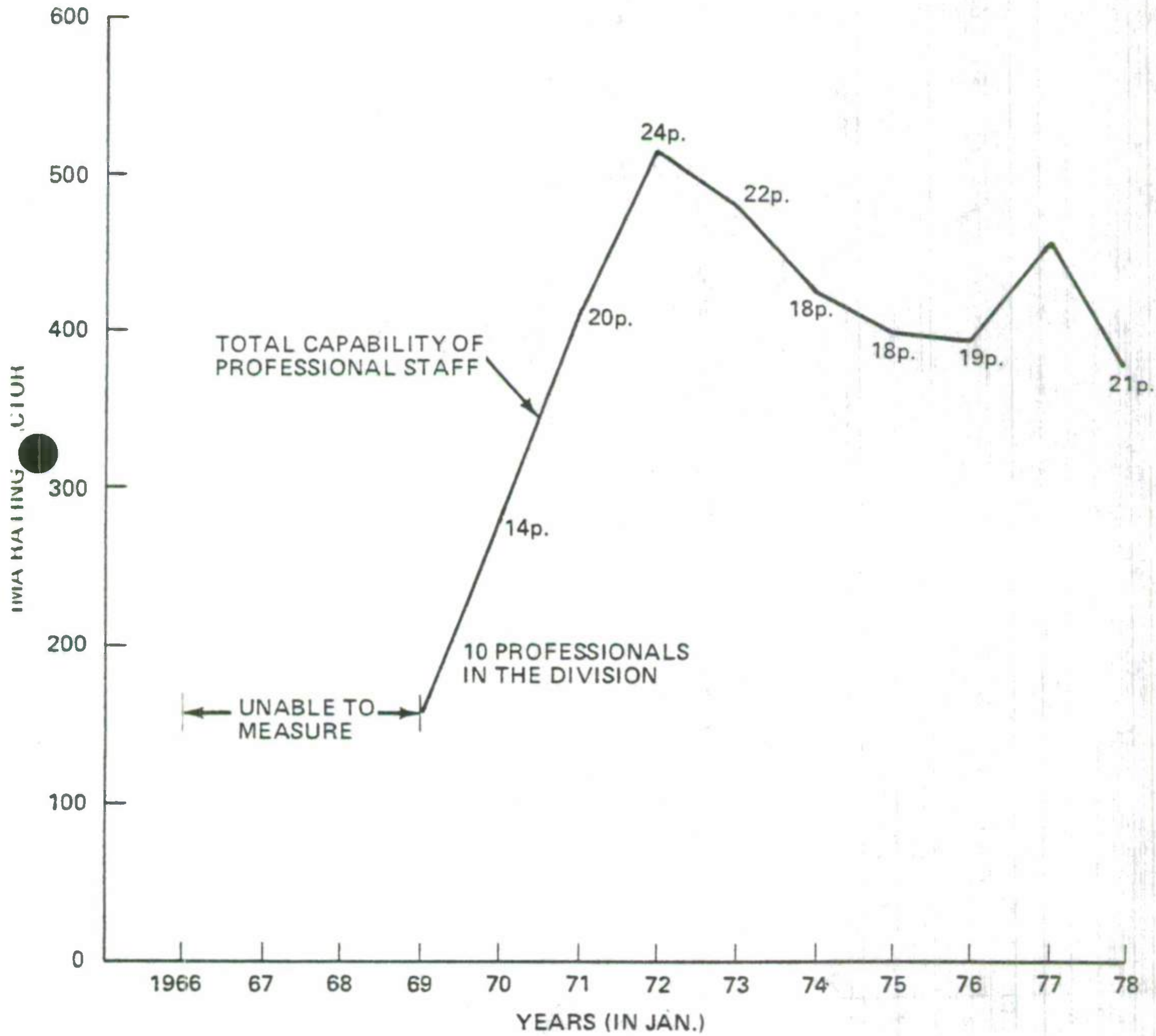
TREND OF AVERAGE CAPABILITY OF PROFESSIONAL STAFF
SEA-01G



PREPARED BY IMA
SEPT., 1977

FIGURE D.14

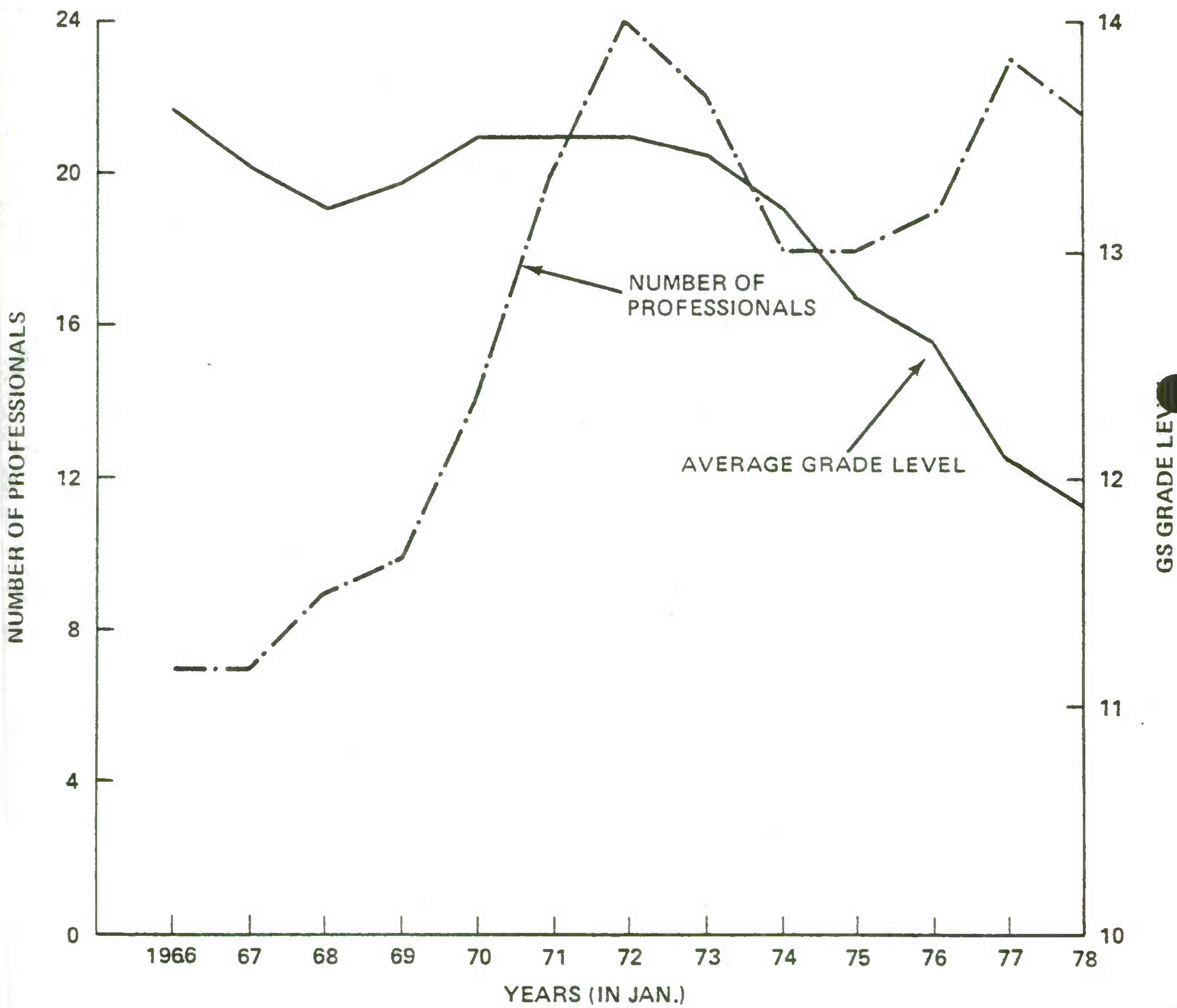
TREND OF TOTAL CAPABILITY OF PROFESSIONAL STAFF
SEA-01G



PREPARED BY IMA
SEPT., 1977

FIGURE D.15

TREND OF AVERAGE GRADE LEVEL OF PROFESSIONALS
SEA-01G



PREPARED BY IMA
SEPT., 1977

in 1976 it still was less than it was at its peak in 1972, when the staff was about the same because of the personnel changes noted previously. Again, the projected total capability will not increase substantially unless addition of experienced staff is possible.

Figure D.15 shows the reducing effect of personnel changes in the past several years on average grade level. A small drop is shown for 1977, which is not conducive to retention of more capable personnel now at lower grades.

Further insight into the capability of the current staff was obtained by a detailed review of education and experience records obtained during the desk interviews. Because the previous graphs present the relative value of these factors collectively, a detailed analysis of education and experience of personnel for past years was not considered sufficiently pertinent and was not done.

(2) The Educational Background of the Current Staff is Exceptionally High

The educational background of the current staff is exceptionally high and is considerably above the level of estimators in the private shipyards surveyed. Bachelor degrees are held by 91% of the staff and advanced degrees are held by 23%. Most personnel in the estimating

group have a mix of engineering degrees; whereas in the analysis group, degrees in mathematics, business and economics predominate. This composition is ideal for the nature of each group's work. The skills are generally well placed. Personnel with additional degrees in computer sciences, or training for computer work, and a law degree further round out the staff background.

The only basic talents considered lacking among the staff are a cost accounting or auditing specialist and a purchasing agent. Both skills would be beneficial to current work and would increase in value if more returned costs were available. In private industry, estimating departments work closely with accounting and purchasing departments for current costs of materials, labor and overhead, and SEA 01G could use the same type of assistance in its task.

An observation regarding the staff's educational background is that it may be overeducated for some of the work required. In fact, a number of people expressed the concern that they cannot work to their intellectual capacity. A well-educated staff without a desirable ladder for promotion can be expected to experience turnover on a routine basis, thereby preventing the overall capability of the Division to grow steadily. In industry, the typical newcomer into an estimating department is

a high school graduate with some college education and considerable experience in the shipyard's production or engineering divisions. More importantly, he considers estimating as a big step-up in his career.

(3) A Lack of Shipyard Experience is Evident

The following set of data shows the experience background of current staff in SEA 01G.

Average number of years of cost analysis or estimating in Navy.	5.7
Average number of years of cost analysis or estimating elsewhere	1.6
Average number of years of shipyard experience	1.3
Average number of years of other construction experience	1.6
Average number of years of engineering experience	4.2
Average number of years of shipboard experience	0.9
Average Years Total Experience	15.3

The average total experience is an adequate background for estimating and analysis; however, it is somewhat misleading as a guide to capability since it is lodged principally in the 39% of staff with 5 or more years of experience. The preceding breakdown of personnel experience (Table D.II) shows how rapidly this group has declined in size. The average 5.7 years of estimating

in the Navy is similarly misleading since it also is lodged principally in the same group.

The most important indicator on the chart relative to capability is the very low shipyard work experience of 1.3 years per person. This is considerably below the average of estimators in private shipyards and is a significant obstacle to material and labor cost analysis and estimating, even for the parametric or analagous methods used. As noted elsewhere, estimators themselves were concerned about their lack of shipyard exposure. The staff would be seriously handicapped because of this factor if it had to make detailed engineering estimates and would have problems with a three digit ship weight breakdown, which it needs now to promote accuracy.

Because of over-education in some of the staff and lack of practical experience overall, the Division could improve in the long range by future recruitment of a few employees with less formal education and more practical training and experience in shipbuilding. It is estimated that there are about 1,500 people classified as planners or estimators in Navy field activities that could be considered as possible sources to draw from for additions to the SEA 01G staff.

(4) <u>The Key Factor in Cost Analysis and Estimating is Judgment</u>

Analysts require judgment to evaluate and interpret large

amounts of varied reference bits, adjust them as needed, and make projections for current and future use in guidance and data banks, because they rarely fit the instant case precisely. This is particularly so since the new SWBS system was established and ships have increased in complexity. Data banks in SEA 01G are relatively old because of the long time it takes to build ships and obtain returned costs. As more recent data become available, they must be thoroughly judged for accuracy and comparability before they can be used with complete confidence.

(5) Training and Experience are Vital

Training and experience in the shipbuilding process are vital to the development of proper judgment in estimators, and somewhat less so for analysts in the work they are presently doing. As previously indicated, SEA 01G is very thin on such experience. Its level of achievement can be attributed to the expertise of a few and also to greatly improving guidance from the Analysis Branch. If some key personnel were lost, the present capability would be seriously depleted.

Various comments about the ability of SEA 01G were made by officials interviewed during this study. In brief they were:

"fine, but very thin"; "thin force that gets hit hard by many at the same time"; "overworked"; "hardly consonant with the money involved"; "good job under the circumstances"; "grade structure is too low"; "too few good estimators"; "needs more staff and talent"; "understaffed"; "thin "; and "should have one estimator per program and not one for four programs". These remarks characterize the same observations made in detailed descriptions of the nature and work of the Division that are presented elsewhere in this report.

Training programs are conducted by Navy to improve skills of all personnel in SEA 01G; however, they do not address themselves to the most urgent need for more shipyard experience. Since the work schedule and lack of travel funds do not permit temporary assignment of present staff in shipyards to gain the requisite experience, it is suggested that additional personnel be obtained as indicated below, not only to provide needed experience and judgment but also to alleviate the existing workload situation.

- A change order estimator from a SupShip Office
- A ship repair cost estimator from a naval shipyard
- An ordnance manufacturing estimator from a naval arsenal or from within NAVSEA 06

Recruitment from Government field offices would serve the interests of personnel policies and provide required practical experience and familiarity with naval work. Addition of these personnel plus an accountant and purchasing agent noted previously would increase SEA 01G's capability substantially to do present work and increase the scope and depth of analysis.

(6) <u>The Most Important Task of SEA 01G is to Make Accurate Class "C" Budget Quality Estimates</u>

These estimates, by definition, are supposed to be based on an engineering analysis. Each estimate is made to represent the expected average of shipyards' bids for the ship involved. Between 40 and 80 manhours are spent in estimating and analysis of any one estimate for each ship project, depending on type of ship and equipment. The work is done two years in advance of requests for bids and, especially for new ship types, is generally based on the few characteristics that are available at the time which are also subject to continuing review and change. They are in a better position on repeat ship types already in production.

By contrast, shipyards prepare their bids from contract plans and specifically in a detailed engineering fashion, using in the order

of 6,000 manhours for a commercial ship and 30,000 manhours for a naval ship. They work with actual labor costs, hundreds of vendor quotations, and timely information from accounting, production and engineering departments. The expected variance from eventual end cost is 2%. A variance of -8% is a major catastrophe calling for personnel changes in the culpable department.

2. WEIGHT ESTIMATES REPRESENTS PRODUCT DEFINITION AND IS PROBABLY THE SINGLE MOST IMPORTANT ELEMENT PRESENTLY GOING INTO NAVY ESTIMATES

In the present estimating procedure, weights are used almost exclusively as a means of translating ship characteristics into a medium for estimating. As described in detail earlier, the usual estimating form consists of multiplying the ship's weight broken down in 7 weight groups by appropriate manhours and dollars per ton to develop the basic ship cost. The weights used are prepared by NAVSEC and they evolve with increased reliability as the ship design develops.

(1) The First Weight Estimating Calculations Are Made During the Feasibility Study Stage

These estimates are computer derived in three digit format; however, due to the nature of the program the total of the single digit sum of the three digit values is reasonably correct. Figure D.16

shows a single digit breakdown and Figure D.17 shows a portion of the two and three digit breakdown to illustrate the refinement of data produced. These weights are only good for developing a measure of merit between a number of concepts or to make a sensitivity analysis.

Computer programs have been developed for a number of ship types using statistical weight data in the form of algorithms. The usual output at the feasibility stage will consist of a single sheet characteristic and the single digit weight read-out. This is considered satisfactory for E or F class estimates.

(2) <u>The Next Stage of Design Development is the Conceptual Design</u>

At this point, one of the feasibility designs has been selected for further development. The degree of design definition at this stage that relates to weight development includes machinery and electrical equipment lists, general arrangement sketches, possibly a midship section, weapon list, etc. From this data a three digit weight estimate is developed primarily by comparing each system with a calculated weight of a similar completed ship. There is no attempt at this stage in the design to make sketches for the purpose of estimating

FIGURE D.16

EXAMPLE OF SHIP BREAKDOWN SYSTEM GROUPINGS

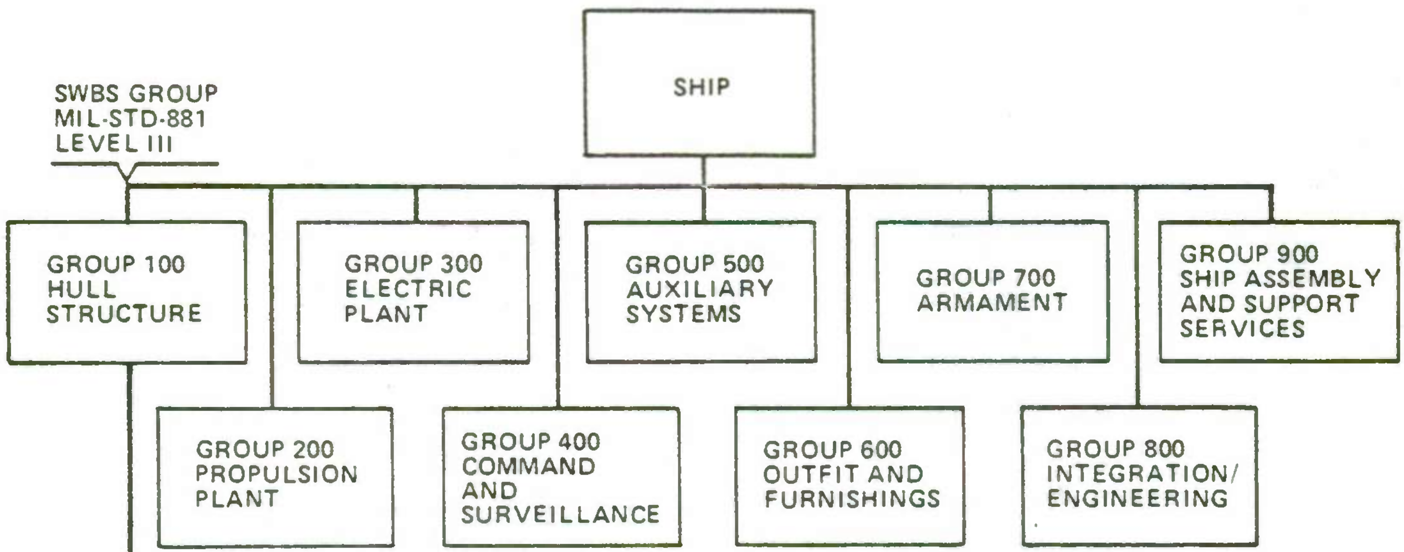
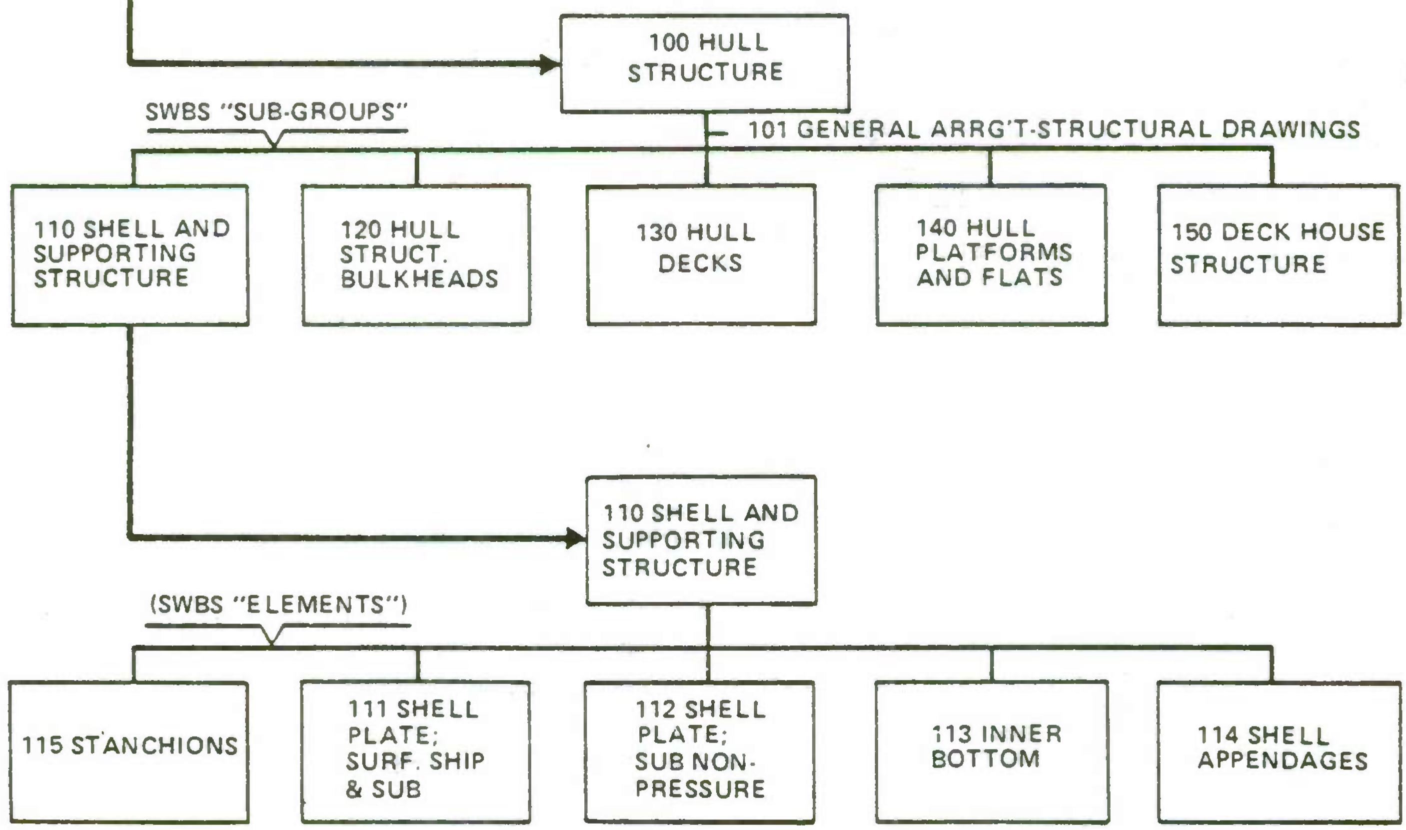


FIGURE D.17



piping systems or electric cable and fixtures. The accuracy of these weights is such that they usually add a margin of 10%.

The data bank is composed primarily of quarterly weight reports and inclining experiment results calculated by the shipbuilder. The weight data is about 90% calculated and 10% actually weighed. At this point in the design the three digit weights are considered to be much better than those in the feasibility stage and good enough for a D class estimate.

(3) The Next Stage is Preliminary/Contract Design

Very often there is not a clean cut-off point between preliminary design and contract design, but as the design passes through the DSARC review it becomes firmer and the weight estimate becomes better. At this point in the design the weight data should be of high quality and reflect the most recent available return weights for ships of the class being estimated. By the time the design meets the definition of a Preliminary Design, a class "C" estimate could be made if time permitted.

(4) <u>Under the Present Organizational Arrangement the SHAPM is the NAVSEC Customer for Design and Technical Services</u>

As the customer, the SHAPM is the primary NAVSEA contact with NAVSEC. Accordingly, communication between SEA 01G and NAVSEC is on a casual basis only and SEA 01G cannot task NAVSEC directly.

Close communication between SEA 01G and NAVSEC is needed in order for SEA 01G to be fully informed on design changes that can and do take place during the period cost estimates are being prepared for the budget. Design changes can have a substantial impact on cost estimates.

As an example, a review of the design and weight input developed by NAVSEC for a small combat ship showed substantial weight growth as the design evolved. Weight growth during preliminary design was 25% and during contract design 8% more growth was noted. A cost estimate prepared during an earlier stage of design, i.e., conceptual stage, could be as much as 30% off from this cause alone.

It is apparent that better estimates can be prepared if direct communication between SEA 01G and NAVSEC is improved and if estimates are prepared on the basis of preliminary design data.

3. SHIPBUILDING PROGRAM COSTS ARE HIGHLY DEPENDENT UPON ACCURATE AWARD AND CONSTRUCTION SCHEDULES

As discussed in detail elsewhere in this report, the task of preparing a ship estimate for inclusion in a five year program, or for a specific budget year, is performed in two rather discrete operations. The first operation involves the preparation of a parametric or engineering estimate for the ship which provides the building block or baseline for use in estimating the cost of a shipbuilding program. The second operation involves the development of program costs given a profile of the number of ships to be authorized each year, information on proposed award dates, construction schedules, procurement plans, escalation rates and the like. These program costs are provided to the Congress in the form of budgets, authorization requests and five year programs. If the schedules by which the ships are to be built are optimistic and delays occur, program costs almost invariably increase.

(1) Ships are not being completed on their planned delivery dates

A review of selected ships authorized in FY 1970, and

later and now under construction was conducted to determine the delay in ship delivery dates as compared to originally planned dates. The information on originally planned delivery dates was taken from data supplied by the Navy to the Senate Armed Services Committee in hearings held in February 1976. Current delivery dates and completion percentages were taken from the December 1976 Monthly Progress Report prepared by NAVSEA. The specific ships considered are listed on Table D.12. The review was limited to ships with 10% or more progress since predicted delivery dates should be more accurate once the work is underway. Reviews also were conducted of ships with 25% or more progress and 50% or more progress to explore the change in predicted delivery dates as work progresses. This review is summarized at the end of Table D.12:

TABLE D.12

SHIP DELIVERY DELAYS

Ship	% Comp.	Fiscal Quarters: Current Del. Date	Fiscal Quarters: Original Del. Date	Fiscal Quarters: Contract Del. Date	Delay: Orig. to Current	Delay: Contr. to Current
FFG 7	69.2	1-78	3-77	2-77	2	3
LHA 2	93.7	4-77	3-73	4-73	17	16
" 3	82.6	1-79	4-73	2-73	21	23
" 4	76.3	4-79	2-74	2-74	22	22
" 5	72.0	2-80	4-74	4-74	22	22
DD 972	94.1	4-77	4-76	4-76	4	4
" 978	93.1	2-78	2-77	2-77	4	4
" 979	90.3	3-78	3-77	3-77	4	4
" 985	81.6	2-79	1-78	1-78	5	5
" 986	81.1	2-79	1-78	1-78	5	5
" 992	78.8	4-79	3-78	3-78	5	5
CVN 69	89.4	1-78	3-74	4-75	14	9
CGN 39	81.3	4-77	1-76	3-76	7	5
SSN 691	80.6	1-78	2-75	1-76	11	8
" 693	69.1	3-78	3-75	3-76	12	8
CGN 40	61.4	4-78	4-76	4-76	8	8
SSN 695	57.2	1-79	4-76	4-76	9	9
17 Ships 50% or more complete						
SSN 699	49.1	2-79	3-77	3-77	7	7
" 700	39.3	3-79	4-77	1-78	7	6
SSBN 726	33.3	1-79	1-78	3-79	4	-2
AS 39	36.0	4-78	4-75	4-78	12	0
4 Ships 25% to 50% complete						
AS 40	22.1	2-79	3-76	2-79	11	0
SSN 705	13.4	4-80	3-78	3-79	9	5
" 706	11.9	1-81	4-78	4-79	9	5
SSBN 727	17.2	1-80	4-78	3-80	5	-2
TATF 166	13.0	4-78	1-78	4-78	3	0
CVN 70	16.9	4-80	4-80	--	0	0
CGN 41	16.9	3-80	1-79	1-79	6	6
7 Ships 10% to 25% complete						

(continued)

TABLE D.12 (cont.)
(Summary)

	10% up	25% up	50% up
Years Delay			
Original to Current	61	50	43
Contract to Current	46	43	40
No. of Ships	28	21	17
Years/Ship			
Original vs Current	2.2	2.4	2.5
Contract vs Current	1.6	2.0	2.4

SOURCES: Senate Armed Services Committee Hearings, February 1976

NAVSEA, December 1976 Monthly Progress Report

Ship cost estimates contained in budget requests are presumed to be based on the originally planned delivery date and, if allowances are made for delays, they certainly are not of the magnitude of the two to two and one-half year average indicated in Table D.13.

TABLE D.13

ORIGINAL VERSUS CURRENT DELIVERY DATES

	10% up	25% up	50% up
No. of ships	28	21	17
Total Years Delay	61	50	43
Years Delay/Ship (Average)	2.2	2.4	2.5

Refined estimates of the impact of these delays on costs can only be made on an extremely detailed ship-by-ship basis. It is possible, however, to develop a rough estimate using manning curves and inflation rates. Figure D.18 shows for the CVN 69 the manning plan used to budget the funds appropriated by the Congress and the current manning plan which is made up of actual manning and a projection to completion. The points at which 50 percent of the direct labor have been expended are 3 1/4 years. As originally

budgeted, about 62% of the costs of the CVN 69 were in the basic construction contract and, thus, subject to this 3 1/4 year delay.

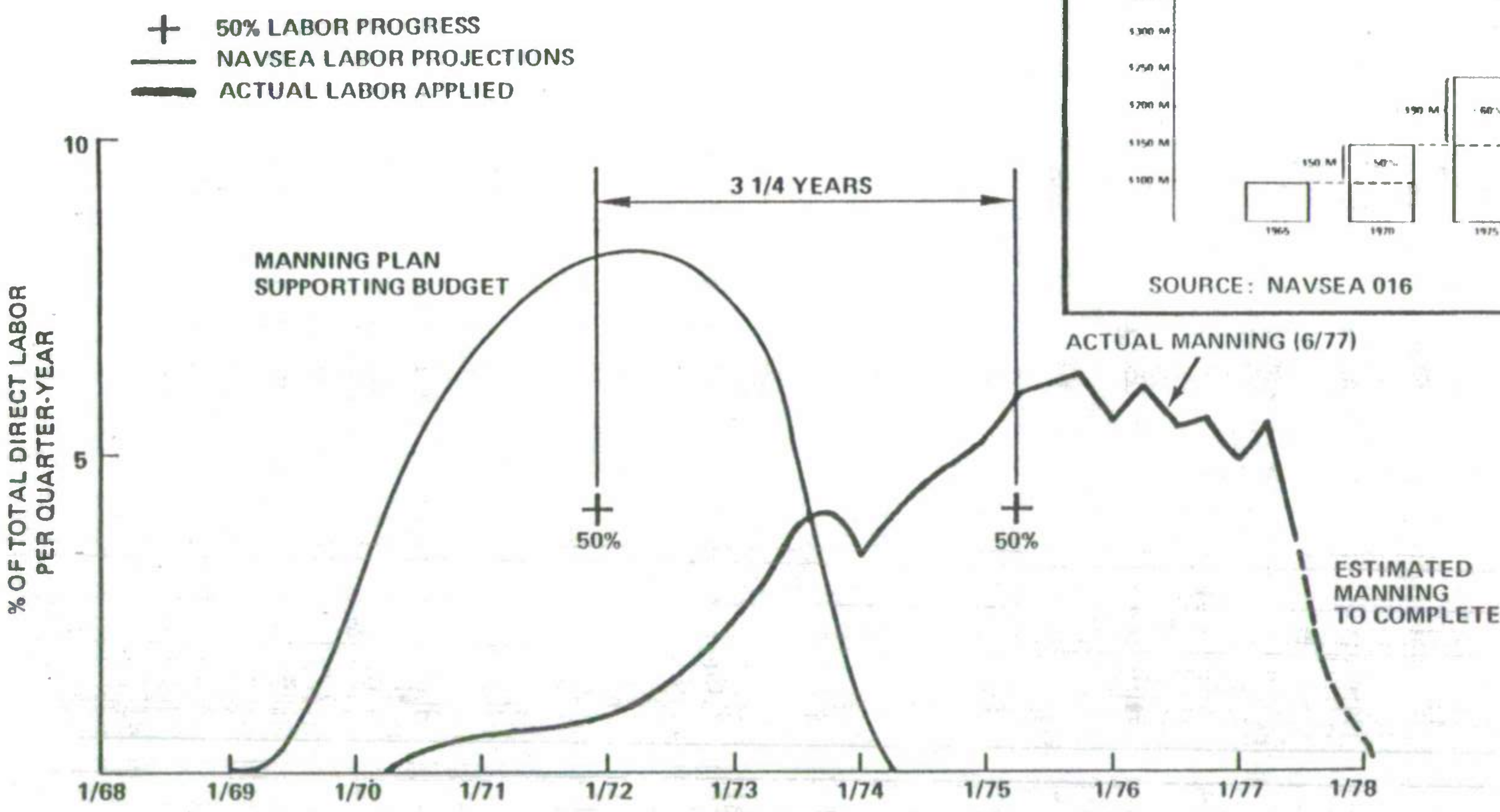
Similar analyses were made for the LHA 2 and the AS 39. The corresponding delays and percentages are: LHA 2, 2 1/4 years, 88%; AS 39, 3 years, 78%.

The cost of these delays was approximated by using the above data and the ship price inflation index, Figure D.19, developed by NAVSEA. Figure D.19, indicates that the inflation in the price of ships is about 11 1/2% per year during the years in which the delivery delays on these three ships are occuring. The costing procedure is shown in Table D.14.

FIGURE D.18

CVN 69

SHIFT IN LABOR APPLICATION

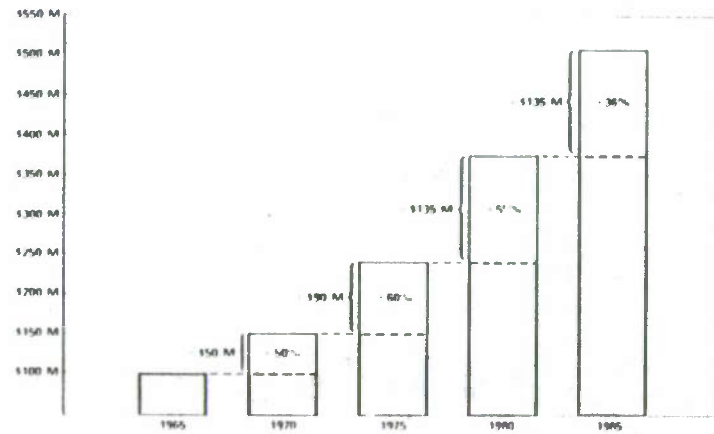


SOURCE: NAVSEA 075

FIGURE D.19

SHIP PRICE INFLATION

(EXACT SAME SHIP NO CHANGE TO SPECIFICATIONS WEAPONS SYSTEMS OR PERFORMANCE)



SOURCE: NAVSEA 016

TABLE D.14

APPROXIMATE COST INCREASE DUE TO
DELAY IN DELIVERY

		CVN 69	LHA2 *	AS39
1)	Congressional Appropriation	$510 M	$144M	$ 93M
2)	Percent in Basic Construction	62%	88%	78%
3)	Amount Expend. at Shipyard (1X2)	$316M	$127M	$ 73M
4)	Years Delay	3 1/4	2 1/4	3
5)	Inflation Factor (4. x 11.5%)	37%	26%	34%
6)	Inflated Shipyard Amount (3+(3x5))	$433M	$160M	$ 98M
7)	Add Back Non-Shipyard Amts. (6+(1-3))	$627M	$177M	$118M
8)	Current Estimate	$734M	$224M	$152M
9)	Percent of Increase $\frac{6-3}{8-1}$	52%	41%	42%

* One-half of LHA 2 and 3 dollar tctals

These percentages are conservative in that no inflation of government furnished material or other non-shipyard costs was assumed. Also, consideration was not given to the fact that the disruption caused by such delays invariably increase costs. Clearly, the delays in delivery beyond the date used in estimating the end cost to be approved by the Congress are a major cost driver. SCN budget requests will be understated if ships are built at a later date than

estimated. Starting with insufficient funds leads to a myraid of downstream pressures and problems that surface later on. These factors include reduction in the number of ships and/or in capabilities which leads to the development of mistrust between the Navy and shipbuilders and the claims of the shipbuilders in the Navy.

(2) Establishment Of Delivery Dates

The Planning, Programming and Budgeting System includes force structure considerations from which the required delivery dates for ships which are to be introduced into the programming and budgeting cycle are determined. The NAVSEA role in this respect is to:

- Continually assess the capability of the shipyards and supporting industry to accomplish prospective work assignments (shipbuilding programs).
- Develop realistic award and production schedules for each ship to be introduced into the programming/budgeting cycle. These schedules should be based on past and current experience with similar ships, lead time studies for components, plans for utilization of specific shipyards, industry-wide forecasts, procurement profiles and the like.

The Sea Power Sub-Committee of the House Armed Services Committee concluded that the shipbuilding industry probably would take steps to develop and retain required capability and capacity if given a five year shipbuilding program. Such a program is now available to the public although, as indicated again in hearings held in March 1977, it is quite unstable from year to year. This same sub-committee also concluded that there was a shortage of

skilled shipyard workers necessitating greater emphasis on training programs. These two actions alone indicate acceptance of the fact that there are limitations on the capacity of the industry.

NAVSEA studies of shipbuilding industrial capacity within the United States recognize these limitations but invariably conclude that proposed shipbuilding programs can be accomplished as planned if the groundwork is carefully laid. It is to be noted that sound information on the labor markets and workload, including shipwork and non-shipwork, to be imposed by other consumers in each area is difficult to obtain, which reduces the value of the shipbuilding industry's capacity reviews.

The planning for individual ship and ship class assignments to shipyards is accomplished in much greater detail. Nevertheless, there are serious limitations having to do with predicting the shipyard that will get the award, the status of other work in hand, initial optimism and production and test problems. During the programming phases the impact of such factors is very difficult to evaluate since long range predictions of workloads, social trends, state of the economy and stability and adequacy of engineering designs are required. Thus, the risk of making a poor prediction is great and a realistic approach is in order. When ships are finally funded

and awards are being negotiated more reliable predictions of these factors should be available and be reflected in the delivery dates established by contract. However, even at this stage of the acquisition when the long lead time material has been ordered, the performing shipyard identified, the design substantially developed and manpower availability assessed, predicted delivery dates have been overly optimistic. This is demonstrated in Table D.15 which compares the average year's delay per ship; namely original vs. currently predicted delivery dates as related to contract vs. currently predicted dates. There is still considerable delay after the contracts are awarded, which demonstrates the over optimism. The ship-by-ship detail are shown in Appendix 1.

TABLE D.15

SHIP DELIVERY DATE PREDICTIONS
(Original vs. Contract Dates)

Years Delay/Ship	Percent Completion 10% up	25% up	50% up
Original vs. Current	2.2	2.4	2.5
Contract vs. Current	1.6	2.0	2.3

The changes being introduced into some new contracts whereby energy price increases, labor and overhead escalation and some other items are being passed through with certain limitations to the government will partially alleviate the shipbuilders' financial problems

caused by inaccurate prediction of delivery dates. But, such measures will not cure the basic problem. Therefore, it is important to improve the capability of setting realistic delivery dates during both the programming and the contracting stages.

(3) <u>Shipyard Manpower Availability Is Critical In Meeting Delivery Dates</u>

There are a number of factors that affect delivery dates e.g., longer than anticipated material lead times (both contractor and government furnished), changes in configuration, unrelenting optimism by both shipbuilder and Navy, and production and test problems.

There are several sources of data on shipyard manpower once an award is specifically planned. These include information developed during pre-award surveys, manpower information provided by the proposing shipyard and reports showing work in hand and manning to completion. These data coupled with estimates of the manning required for potential new Navy work form the basis of shipyard-by-shipyard workload projections. During the ship programming stages when original budget estimates are submitted such information is either not available or is less accurate due to the years of projection

required. Additionally, information on future work for customers other than the Navy and on the capability of the local labor market to adequately support an increased volume of work is not developed regularly to support delivery date predictions for either programming or contracting.

It is difficult to forecast workload and manpower available in future years, yet, such forecasts are an essential element in setting the delivery dates which have such a major influence on cost growth. Therefore, this area deserves greater attention and better organization at both the headquarters and field levels. It appears logical that SEA 075, the Ship Production Office, should strengthen its capabilities in this area, deriving increased support from government manpower organizations , the Maritime Administration, industry and from the Supervisors of Shipbuilding, Conversion and Repair, USN.

(4) NAVSEA Organization Divides Estimating Responsibilities

The present NAVSEA organization for ship acquistion estimating is divided, leading to divided responsibility. SEA 01G, the Cost Estimating and Analysis Division, develops cost estimates for specific ships and, also, certain adjustment factors having to do with overhead, escalation and the like. SEA 075, the Ship Pro-

duction Office, is responsible for assessing shipyard capacity and developing production schedules for all ships in the shipbuilding program so this too is an estimating function. The products of these two organizations must be placed under one supervisor. As, presently organized, the lowest level of common supervision is the Vice Commander of NAVSEA who has a broad range of responsibilities. Moreover, the supervisory levels immediately above these two organizations do not have shipbuilding program responsibilities as a primary duty. One is the Comptroller (SEA 01) and the other is responsible for naval field activity management (SEA 07).

Several years ago when there was an assistant chief for shipbuilding, Bureau of Ships, the now SEA 01G and SEA 07 reported to a common supervisor whose primary duty was shipbuilding. There was no division or responsibility.

It is considered that the budget estimating would be improved if these two organizations were placed under common supervision without delay.

V. PROBLEMS ENCOUNTERED IN PREPARING BUDGET QUALITY ESTIMATES

Many detailed problems in analysis and estimating were noted previously and other observations relative to estimating capability have been made in this section of the report. The most pertinent items are briefly summarized below.

1. CLASSIFICATION OF ESTIMATES AS BEING OF "C" QUALITY ARE OFTEN UNREALISTIC

Single sheet characteristics and the time spent in developing estimates therefrom are very often inadequate for the desired level of confidence for a class "C" estimate. Many "C" estimates should be considered as "an approximate order of magnitude" estimate.

2. MOST GFM COST INPUTS ARE UNCONTROLLABLE AND NOT SUBJECT TO REALISTIC VERIFICATION

The SEA 01G utilizes cost inputs from other System Commands for weapons, electronics, nuclear propulsion and other Government Furnished Material and cannot exercise judgment that is equal to that given other elements in the ship cost estimate.

3. SHIP WEIGHT ESTIMATES ARE FURNISHED SEA 01G

Ship weight data are furnished by NAVSEC for seven groups of the nine group breakdown used for bids. SEA 01G has no measure to validate these weight estimates.

4. BUILDING SCHEDULES FURNISHED TO SEA 01G

Large cost errors result when the delivery dates upon which the estimates were based are missed. Provisions are made in estimates only for escalation during an average delay period of seven months; whereas much longer delays are being experienced on many ships. Also, contingency pricing for overhead and other factors of cost is not permitted for extenstions in delivery dates. When a contract is delayed beyond its expected schedule, the budget estimate cannot be adjusted, but the costs of material, labor, and overhead increase by the rate of inflation in the economy during the length of the delay period. This could be to ten percent of the end cost estimate for one year of delay.

5. PARAMETERS FOR ESTIMATING ARE TOO GROSS

Dollars per ton for material and manhours per ton for labor are sound parameters for similar hull work, but are too insensitive for machinery, electric plant, and outfit. These groups contain such a variety of components of different costs per unit of weight as to require sub-groups with their own cost parameters for accurate estimating. It is recognized that timing in the procurement cycle prevents the preparation of sub-group weight estimates; hence an inherent inaccuracy will exist in basic ship estimates made with gross parameters, except where the ships are very similar in all principal characteristics. Aircraft carrier and submarine estimates have the best chance of being accurate so long as they are repeat designs.

6. DATA BANKS NEED UPDATING AND UPGRADING

Except for ship types being built with regularity, data banks are old and cannot be used with complete reliance, because ship complexity and modern shipbuilding techniques are not comparable to prior baselines. Even some of the more recent bid information needs upgrading to Navy's SWBS accounts. More returned costs should be analyzed and converted to usuable form to replace excessive dependency on former bids and in-house estimates. The more reliable the data possessed by ship types, the narrower the margin of error will become, particularly in the determination of average parameters, which are heavily used by estimators.

7. ADJUSTMENTS FOR PRODUCTIVITY AND LEARNING MAY BE UNWARRANTED

Normally expected improvements in productivity of labor, management, and facilities have not been evident in recent years, and are not applied in current estimates. As noted previously in Chapter III, downward adjustments are being applied now, as producitivty has decreased. However, increasing productivity resulting from learning on multi-ship projects is expected, to some degree, by higher echelons in Navy and is included in estimates on a conservative basis, although SEA 01G does not have complete confidence that it will fully develop.

Award of contracts for a multi-ship program to two or more builders upsets the learning curve predictions adversely, but a budget estimate that anticipated an award to only one shipyard cannot be changed.

8. ECONOMIC ADJUSTMENTS ARE DIFFICULT TO FORECAST

Although the Analysis Branch developed good methods for tracking inflation, labor rates, etc., and has demonstrated a better record than other government agencies for cost adjustments, it still suffers from the inherent human inability of foreseeing the future. The span of time for shipbuilding contract forecasting is up to nine years, which is much too long a period for prior assumptions to go undisturbed especially in an era of shortages and economic aberrations. Industry's ability to forecast is no better, hence a variance in estimates of end costs, regardless of source and classification of quality, must be expected.

9. MARKET PREDICTIONS ARE VERY IMPORTANT

The potential bidders on a few classes of ships can be determined quite well by methads used by SEA 01G, but on remaining classes bidders become considerably less certain. In the two year interval between the budget estimate and receipt of bid, market conditions can affect the price of the ship by as much as 15-25 percent (See Figure D.9). In the pre-contract award phase the market factor is the largest single element that can affect an estimate, regardless of its technical accuracy.

Unless upset by a variance in the predicted market, profit estimates are sound. They are based on ASPR and fall in a range of 10-15 percent, depending on the estimator's judgment of risk and uncertainty connected with the ship involved.

10. COST GROWTH MARGINS ARE UNCERTAIN

Percentage adjustments are made for basic ship construction, weapons and other GFM to provide for change orders, which are a normal part of the shipbuilding process. The cognizant SHAPM adds to the amounts submitted by SEA 01G, if appropriate, according to his assessment of the project. Some unexpected charges and assessments over which the SHAPM has na control often emanate from other Navy offices to destroy the margin.

VI. IN ORDER TO MAKE A SUBSTANTIAL IMPROVEMENT IN THE QUALITY OF TOTAL SHIP COST ESTIMATES MAJOR CHANGES IN PROCEDURES WILL BE REQUIRED

So far in the pursuit of this study some findings have become evident that must be recognized in order to place the observations that follow in their proper context. The Navy in FY 1979 plans to budget for new ships about $8.2 billion. In the expenditure and the future planning to spend such sums, the United States has a right to the finest system of ship acquisition that the state of the art can devise.

1. THE MAJOR DETERRENT TO ESTABLISHING FISCAL CREDIBILITY IS INSTITUTIONAL

First, the Federal budget process requires that firm estimates for ships that are still in conceptual design phase be established at least two years before contract award and three to four years before work actually begins. During this period, design development and changes in the general economic climate can, and we believe will, continue to play havoc with the budget estimates.

Second, the shipbuilding program is in a continual state of flux. Changes are continually made to accommodate new threat discoveries,

fiscal restraints and political philosophy. These changes in program and building schedules can have a major impact on program costs.

Third, the Navy's basic mission is to defend this nation, and as it is primarily a fighting force, it does not have a profit or fiscal awareness found in corporate organizations. This lack of cost consciousness has in part resulted in an unprecise cost estimating capability for both ships and weapons.

With these three basic facts of life in mind, the first is beyond reasonable Navy control. The Navy in the second can be more realistic about anticipated ship construction schedules. The third is an area where the Navy could do more. The possibilities range from placing all ship and weapon design and procurement in a separate 100 percent civilian manned agency anwsering to the Secretary of the Navy, to making a few substantive and cosmetic changes to the present estimating procedure.

Since it is beyond the scope of this study to examine and evaluate the numerous reorganizational possibilities, observations regarding possible improvements in ship and weapons estimating will be confined to what may be possible in NAVSEA, to a limited degree OPNAV, and other commands. First, however, there are two general observations regarding SEA 01Gs performance that have evolved. It is the finding that SEA 01G is only minimally capable of consistently providing the quality of estimates expected for all classes of

ships. Its present organization is insufficient in number to handle the workload properly. Some essential skills and supervision are absent. The level of practical experience among a large percentage of personnel is low. Their assignment is difficult because of poor product definition for the quality of estimates required; insufficient time; lack of control over large amounts of GFM costs, ship weights, and construction schedules; and the long span of time involved in necessary economic forecasts.

On the positive side, leadership and key personnel in the division are experienced and form a solid base upon which to improve capability. The Cost Analysis Branch has developed a negligible guidance base to a greatly improved one in about four years. An equal effort is required to provide more sensitive estimating parameters based on returned costs, to replace some of those presently used, and to update data banks to current work breakdown systems.

2. OBSERVATIONS REGARDING STEPS REQUIRED TO IMPROVE PERFORMANCE FALL INTO TWO CATEGORIES

First it is believed that the quality of ship estimates including GFM can be substantially improved if firm standards are established along with organizational changes and additional resources.

The second category of items are directed toward making the present estimating system work better, but without any real assurance that estimates will improve.

(1) Category I

- Establish a well defined standard for ship and weapon description as a basis for the budget year and POM year. This should include -

  - Preliminary design (by Navy definition)

  - Weight estimates in three digit breakdown for each ship system

  - A complete equipment list for all components with a value of $10,000 to $25,000 (depending on ship type) and over

  - In addition, because of a consistent record of naval program slippages, an industry capacity analysis should be made to establish realistic contract award dates and building period.

- Establishment of a directorate which would include the function of ship construction estimating and production planning is favored. (This would include the current functions of SEA 01G and SEA 075). This directorate within NAVSEA should have the responsibility to prepare and to make all ship construction estimates, validate GFM estimate, and estimate GFM as required. It should also be responsible for determining feasible construction periods based upon a continuous assessment of the shipbuilding industry's capability to respond to all of the demands upon it -- military and civilian. This change of command recognition for the estimating and planning functions would have to recognize the responsibilities of the SHAPMs under their present charter. By increasing the capability of the estimating and production planning group, the SHAPMs should be more effective and less prone to advocate overly optimistic budget estimates and building schedules.

- Give this new directorate funds and/or authority to task for services from other organizations such as:

  NAVSEC
  DCAA
  PARMs
  SupShips
  Naval Shipyards
  Contractors

- Establish a system whereby returned costs are collected in a timely manner from shipyards and suppliers of GFM and processed into a form usable in making future ship and GFM estimates and validation of GFM. This may require changes in ASPR.

- Secretary of Navy to issue instructions to prohibit the release of any estimates for the current year budget and the first out year unless certified by Commander of NAVSEA that they are of actual budget quality.

- The CNO to issue instruction to limit tasking the NAVSEA Shipbuilding Directorate to meaningful estimates in order to maintain estimate quality.

- Staff the new directorate as necessary to carry out its function with optimum efficiency.

(2) <u>Category II</u>

- Additional experienced estimating staff is needed in SEA 01G.

- Develop within SEA 01G a capability to make independent estimates for GFM.

- All files, reports, directives, etc., whether the property of the Division or personal, should be indexed, and cross-indexed as needed, to inform all personnel about available resources and to facilitate its location with a minimum of effort.

- All economic forecasts and estimates should be compared systematically with actual results on a routine basis.

- All returned costs and bid back-up data located within Navy should be available promptly to the estimators.

- All personnel should visit shipyards and ships occasionally to increase their knowledge of practical matters and make contacts within Navy's field offices for expedient exchange of information.

- Orientation in contracting and claims settlement should be given to the entire staff to develop an appreciation of the importance and interrelation of estimating to these processes.

VII COST RELATED ESTIMATING AND ANALYSIS FUNCTIONS

1. COST ANALYSIS STUDIES ARE IMPORTANT IN DECISION MAKING PROCESS

The overall review of the cost estimating functions in NAVSEA must also include an understanding of the many cost related estimating and analysis functions assigned to the Command and their impact on the basic ship acquisition estimating process. These related functions are reviewed in this portion of the report and cover a wide range of interests that generally entail some degree of cost estimating expertise, but not always as the main thrust of the project.

The need to conduct these studies as outlined in the many directives has been emphasized by DOD and its various military components, including the Navy. This has also been stressed in Congressional reports as a means of assuring maximum return in an ever increasing military budget. Unless some of the many cost related study requirements are reduced, it will be necessary to continue to have cost analysis studies performed.

2. COSTING FUNCTION RESPONSIBILITIES VARY WITHIN EACH ESTIMATING ORGANIZATION

Within various centralized cost estimating groups in the Department of Defense and private industry, the assigned functions and disciplines vary

significantly. This is discussed in great detail in the section of the report which analyzes the NAVSEA and other estimating organizations. Figure D.22 in Chapter X -- "Comparative Analysis, NAVSEA versus Other Estimating Organizations" -- relates the many estimating factors with the responsibilities of a number of selected estimating groups.

The review of these various estimating organziations indicates that NAVSEA's basic estimating group, SEA 01G, has been delegated a great number of cost related functions, some of which may not normally be performed by other estimating groups.

For example, in the private shipbuilding industry the regular cost estimating group's prime responsibility is to provide the necessary material and labor cost estimates for price proposals and bids. The estimators, however, are not generally responsible for procurement disciplines and cost analysis functions. The final pricing, which is dependent on many business variables and decisions, is accomplished by the corporate management. As is indicated in Figure D.22 in Chapter X, SEA 01G has a broader responsibility in developing estimating factors than the shipyard estimators. Similarly, SEA 01G has more responsibilities than the other military estimating groups reviewed in this study.

3. COSTING FUNCTIONS COVER A WIDE SPECTRUM OF ESTIMATING AND ANALYSIS CONSIDERATIONS

As already partially discussed, there are a number of functions that may be performed by central cost estimating groups. SEA 01G separates these functions into the broad categories of acquisition estimating, procurement disciplines, cost analysis functions and other related items. Each one of these and their subgroups were separately discussed in detail in Chapter III to indicate the differences in definition, purpose, principal directives, NAVSEA responsibilities and general performance to date. A review of each function indicates that NAVSEA may be required to undertake any or all of these functions at any time in its cost-oriented decision making efforts.

A listing of each of these categories and subgroups and a brief definition follows:

Acquisition Estimating

- Conceptual/Parametric -- defined elsewhere in report
- Budget -- defined elsewhere in report
- Contract -- defined elsewhere in report

Procurement Disciplines

- Contract Cost Analysis -- defined elsewhere in report

- <u>Technical Analysis Review</u> -- a structured in-depth analysis of a contractor's proposal by a team of Government technical experts.

- <u>Should Cost</u> -- a concept of contract pricing based on an in-depth cost management and production analysis at the contractor's plant for the purpose of developing a realistic price objective which reflects reasonable, achievable economies and efficiencies.

Cost Analysis Functions

- <u>Economic Analysis</u> -- a formal structured systematic approach to the problem of choosing how to employ scarce resources and an investigation of the full implications of achieving a given objective in the most efficient and effective manner.

- <u>Economic Forecasting</u> -- relates to the development of labor and material cost trends and indices.

- <u>Life Cycle Costing</u> -- an acquisition technique which considers research and development, investment, operating and support and other costs of ownership in the decision-making process and in selected cases for the construction of weapon systems, equipment , hardware and related items.

- <u>Design-to-Cost</u> -- means selecting a unit cost goal and developing a product with that goal as the principal parameter.

- <u>Cost Modeling</u> -- an estimating tool wherein a set of mathematical relationships is arranged in a systematic sequence to formulate a cost methodology in which outputs (cost estimates) are derived from inputs (descriptions of equipment, organization or system).

Other Related Items

- <u>Overhead Analysis</u> -- the intensive review of current overhead (or indirect) cost elements, i.e., labor related variable costs, semi-variable costs, and fixed costs as a means of

predicting possible changes in shipyard overhead for use in future cost estimates.

- Field Audit -- the review and evaluation of field activities relating to policies, procedures, methodology, and capability to perform cost estimating.

- Specialized Program/Software Costs -- relate to estimates for specific areas of acquisition contract requirements that may or may not be hardware oriented.

- Cost Estimate Validation -- the critical review process that validates all cost estimates and related cost analysis efforts within Headquarters prior to release by the SYSCOM as an official cost estimate.

- Central Cost Monitor -- the organizational unit which acts as the SYSCOM focal point for establishment of estimating policies and procedures to be followed by organizations and individuals not within the established central cost estimating group.

- Documentation -- relates to maintaining complete records covering the entire history of ship and GFM acquisition estimates, their development, assumptions and data sources, and modifications and reason therefore.

- Contract Cost Data Reporting -- replaces the series of performance reports, that have been known in the past as CERs, C/SCSCs, etc., that were to be periodically submitted by contractors to insure that contract performance and costs are being obtained.

4. BOTH COSTING AND RELATED FUNCTIONS HAVE BEEN ASSIGNED TO NAVSEA 01G

The assignment of responsibility of the focal point for the performance of costing and related functions within NAVSEA has evolved over several years and been delegated to SEA 01G or its predecessors. Most of the assignments were added without regard to resources, thus, compliance with some of the directives has been fragmentary and, when accomplished, has necessarily been on a priority basis.

The Cost Estimating and Analysis Division (SEA 01G) has two basic functions. The first covers the development of credible cost estimates and the second is for cost analysis and cost related functions. Some of these, such as economic forecasting and overhead analysis, are required in preparing an estimate. The Cost Estimating Branch's (SEA 01G1) functions are broadly comparable to those of a shipyard estimating group. The Cost Analysis Branch (SEA 01G2) develops much of the normal shipyard management input which is applied to the basic material cost and labor manhours developed by the estimators, with the end product being a bid or price estimate. This

management input is in the category of overhead, anticipated labor availability and wage rates, market, profit, shipway availability, escalation, etc. In addition, SEA 01G2 Cost Analysis Branch participates in system and cost analysis studies of the type usually are not undertaken by a shipyard. Thus, the NAVSEA Centralized Cost Estimating and Analysis group SEA 01G has been assigned a broader range of responsibilities than other centralized Government estimating groups and well beyond that associated with the private shipbuilding industry as indicated in Figure D.22, Chapter X.

5. RESPONSIBILITY FOR CERTAIN COST RELATED FUNCTIONS COULD BE ASSIGNED ELSEWHERE OTHER THAN NAVSEA 01G

In the absence of a cost related analysis group within NAVSEA, these responsibilities, whether directed or implied, have been placed in SEA 01G with some logic. Many functions are directly related to estimating such as Economic Forecasting and Technical Analysis Review. Some are only remotely related, such as, Should Cost, Design-to-Cost, and Life Cycle Cost, the undertaking of which requires primary skills of other Navy groups. Basic cost estimating and cost analysis skills are only an adjunct to the studies. The responsibility for these latter functions might well be located elsewhere within the Command without affecting the basic responsibilities of SEA 01G. Conversely, those functions normally performed by shipyard management in finally pricing the total labor and material costs, should logically be retained and performed by

SEA 01G. Some management considerations in developing a detailed estimate are:

- Overhead factors*
- Market conditions
- Wage rates
- Wage and material escalation
- Manpower availability
- Productivity
- Profit
- Ability to meet contract schedules
- Shipyard interest
- Learning curve
- Special cost drivers

6. COMPLIANCE WITH COST RELATED FUNCTIONS LIMITED BY SEA 01G STAFF

Due to limited SEA 01G staff, compliance with many of the directives is currently on a selective basis. Assignments are undertaken with consideration of general staff workload and on priorities established by higher level organizational units outside of, or within NAVSEA, discretionary priorities are thus established.

The present limited compliance with performing cost related functions is already affecting the ability of SEA 01G to meet its basic acquisition estimating and associated cost analysis responsibilities. Additional cost related function level assignments will further dilute SEA 01G capabilities.

* This includes indirect labor, fringes and benefits, shipyard maintenance and repair, energy costs, office expenses, taxes, interest, water, etc.

7. SOME COST RELATED FUNCTIONS SHOULD PROPERLY BE THE RESPONSIBILITY OF SEA 01G WHILE OTHERS COULD BE ASSIGNED ELSEWHERE

As already indicated, SEA 01G is responsible for developing complete acquisition estimates, including input of cost estimates and various management factors for constructing the proposed ship system. Many cost related functions are required as part of the "shipyard management" input, while others are used to establish programs and policy matters. Thus, cost related functions may be divided into two groups, namely (1) those which should properly be the responsibility of SEA 01G, and (2) those which could be located elsewhere in the Command without affecting the basic estimating function of SEA 01G. Regardless of who is responsible for these cost related functions, NAVSEA's centralized cost estimating group must continue to lend its estimating expertise as a member of the study or analysis team.

8. FINDINGS

The detailed review of the various related cost estimating and analysis functions indicates that SEA 01G should continue to be responsible for the following functions:

Conceptual/Parametric Estimating
Budget Estimating
Contract Estimating
Contract Cost Analysis
Technical Cost Analysis
Economic Analysis
Economic Forecasting
Cost Modeling
Overhead Analysis
Field Audit
Specialized Program/Software Costs
Cost Estimate Validation
Central Cost Monitor
Documentation

The review also indicates that some cost related functions could be primarily assigned to other NAVSEA organizational units, but with SEA 01G cost input as required. These functions are:

Should Cost
Life Cycle Cost
Design-to-Cost

SEA 01G is insufficiently staffed to fully perform its many assigned duties.

The NMARC study emphasized the need for cost analysis studies. It was also cognizant of the functional responsibilities that have been added to the Commands. The report states:

> "Functional responsibilities have been added to the established cost estimating groups without added resources to carry out the functions. Functions such as economic forecasting, economic analysis, and support for life cycle cost and design-to-cost, all of them important, have been added during periods when staff increases have been virtually unobtainable and, in the instance of NAVSEA, when staffs have been actually reduced. This work dilutes the efforts required to perform the basic acquisition cost estimating responsibility and reinforces the need for additional staffing."

9. CONCLUSIONS

SEA 01G should retain the responsibility of properly performing the many cost estimating, cost related, and cost analysis functions discussed above, with the exception of should cost, life cycle cost and design-to-cost. The main thrust in these studies lies in areas other than estimating. These three cost related functions could be assigned to other NAVSEA organization units, or alternatively, SEA 01G should be adequately staffed if it is to retain the responsibilities.

Additional SEA 01G staffing is required to perform all its assigned duties.

10. TECHNICAL ANALYSIS REVIEW (TAR)

Definition

This review is a structured, in-depth analysis of a contractor's proposal by a team of government technical experts. The Technical Analysis Report is a formal summary of the Technical Analysis Review in terms of material quality and quantity and labor manhours.

Technical Analysis differs from a Should Cost Study in that the analysis accepts the contractor's present work practices and bases its review on historical data and not the most efficient or economical work practices.

Purpose

The primary objective of the TAR is to provide the Contracting Officer with comments and recommendations on the acceptability and reasonability of contractor's proposals. The TAR report forms the basis for the Navy's position during negotiation. All negotiated procurements require a "Business Clearance" (request for authority to contract) which is prepared by the Contracting Officer. The Business Clearance is based on information from the TAR and other

sources and is approved by NAVMAT. Pre and post negotiation Business Clearances may include comments and the following analyses:

- Material quality and quantity
- Labor manhour factors and manhours
- Material costs, labor rate and overhead
- Nuclear requirements (nuclear vessels only)
- Contractors changes to "Terms and Conditions"

Principal Directives

ASPR 3-801.2 requires that the Contracting Officer avail himself of all appropriate organizational support such as specialists in the fields of contracting, finance, law, contract audit, engineering and cost analysis. The responsibility of SEA 01G to undertake TAR studies is contained in NAVSEAINST 5400.1. The TAR procedure is detailed in the TAR Guidance Manual presently being placed in the NAVSEA Instruction series.

The bid proposal, when received, is reviewed by SHAPM, Contracting Officer and SEA 01G to determine whether a TAR should be undertaken. If the proposed contract is sole-source, then a TAR

is mandatory, but it can be done in other cases. The TAR team is organized as follows, with the cognizant organizations indicated:

Function	Responsibility
Coordination of technical inputs	SEA 01G or SHAPM*
Material quantity and quality	NAVSEC or SupShip*
Material quotes and forward pricing	SupShip or DCAA*
Manning levels (direct and indirect), labor and overhead rates	DCAA
Manhours, direct and indirect, make/buy decisions, farm-out items	SEA 01G or SHAPM*
Delivery dates, labor and material phasing	SEA 071/SHAPM
Terms and conditions, make/buy decisions, contractor liaison	SEA 022/00L

The organizational structure of the Negotiation Team is listed below along with responsibilities. The Contracting Officer is the focal point of all dialogue.

. Contracting Officer	Negotiate contract
. DCAA	Audit report and subcontractors pricing review
. TAR Project Engineer (SEA 01G or SHAPM)	Non-nuclear cost analysis, TAR report

* Choice is made by Contracting Officer in concert with SHAPM.

- Nuclear Project Engineer (SEA 08) — Nuclear Cost analysis
- PMS (SHAPM) — Delivery schedule, technical requirements

Action Code in NAVSEA

The Contracts Directorate (SEA 02) has the responsibility of (1) procurement policy development and contractual documentation support, (2) contracting for ships, weapon systems, equipment and related services and (3) claims processing and field contract administration support.

SEA 01G Responsibilities

The Cost Estimating and Analysis Division, specifically SEA 01G23, is responsible for acting as leader for TAR teams as required and reports to the responsible Contracting Officer in SEA 02.

Identification of Tasks Assigned to SEA 01G

Over the past seven calendar years, SEA 01G has participated in nine TAR studies. The most recent effort, in 1976, was a very detailed analysis of the Trident Submarine acquisition (Hull #730 with options) completed by the TAR team which was composed of nine

members. Two were assigned from SEA 01G for a total of three months (or six man-months of Division effort).

Progress on Tasks

The only TAR study still underway and not completed is DD 993.

Estimated Time Spent Last Two Years

The following TAR team manning was developed:

Calendar Year	Program	SEA 01G Members	Duration (Months)	Total Team Members
1975	FFG 7	1	3	7
1976	Trident (Hull #730)	2	3	9
1977	DD 993	1	2	22

It appears that an average of about eight man-months per year of effort, in recent years, is the time that SEA 01G has been able to allow for TAR efforts. While SEA 01G's efforts have been beneficial in obtaining a valid Navy position for negotiation, there have been numerous areas where only a cursory review of a cost element has had to suffice. This is due to the time constraints of the TAR and the limited manpower which SEA 01G can dedicate to the TAR.

Impact on Other SEA 01G Functions

Time records indicate that considerable staff effort is required to undertake TAR studies which periodically affects the SEA 01G ability to meet other cost analysis and/or cost estimating requirements. A complex ship such as the CVN required the services of three men over eight months with others participating on a part-time basis. However, this is not a yearly occurrence.

Benefits to Navy Budget or Manpower

The completion of TAR studies gives the Contracting Officer the knowledge with which to negotiate reasonably priced contracts. The experience gained by SEA 01G personnel is most valuable as this is an aopportunity to deal directly with their counterparts in the shipyard.

Discussion

The development of TAR studies as a fundamental negotiating tool requires considerable expenditure of manpower throughout NAVSEA. The contribution of each individual team member varies from project to project. The spectrum of SEA 01G involvement varies from the situation where a SHAPM has the experience and the personnel to perform a TAR completely from within the staff of the project office to

the occurrence of a major, detailed analysis where as many as two or three SEA 01G personnel are solely dedicated for six to nine months.

Findings

TAR studies are required to provide a proper base for evaluating proposals and bids and for negotiating contract awards. The overall emphasis required to develop a more complete data base and to provide greater unit cost capability will permit more useful participation in TAR procedures. The equivalent services of one full man-year is required by SEA 01G.

11. SHOULD COST

Definition

Should Cost, is a concept of contract pricing that employs industrial engineering, accounting and general business management skills in conducting a coordinated, in-depth cost, management and production analysis at the contractor's plant. This major-type of review will identify uneconomical or inefficient practices in the contractor's management and operations and quantify the findings in terms of their impact on cost; and develop a realistic price objective which reflects reasonably achievable economies and efficiences.

This is generally accomplished through a two step approach. The first is to identify and implement near term improvements. The second step is to identify and implement long term improvements. The major cost savings will result from the second step.

Should Cost, in a lesser sense, is also a validation during price negotiations of various cost factors submitted as part of a contractor's proposal.

Purpose

Should Cost is an additional analyzing tool which is also used in the negotiation process. In major management reviews, Should Cost involves sound industrial engineering and management principles which go considerably

beyond cost analyses. It identifies instances of omission or commission in the performance of planned or existing work which could compromise attainment of realistic schedules, performance and cost objectives. A Should Cost study may be required for any of the following reasons:

- When a reasonable price cannot be negotiated with a sole source producer using in-depth cost analysis.

- When a sole source producer has a history of poor cost estimating.

- When a contractor becomes a sole source producer after having greatly overrun a competitively obtained, cost-type development contract.

- When it has been deemed advisable for reasons of standardization, logistics support, etc., to stay sole source with a producer and future requirements are extensive.

- Where it is determined that a sole source producer's costs cannot be made reasonable by the use of contract types.

- When the objective is to control and reduce costs as a long range objective as distinguished from the short range pricing for a particular contract.

- For the definitization of a letter contract or the setting of firm targets under a fixed price incentive, successive target contract.

These major Should Cost studies can be performed by Government teams, by private consultants or organizations, or a combination of Government and consultants.

Principal Directives

The new ASPR requirements pertaining to Should Cost reviews are set forth in ASPR 1-337. The Chief of Naval Material PPM-No. 55 of December 15, 1976 sets forth the CNM policy on these reviews and revises Naval Procurement Directive (NPD) 1-337 on Should Cost as follows:

(a) ASPR 1-337 requires Should Cost reviews for programs requiring DSARC approval or a contracting officer's determination as to why a Should Cost review is not justified.

(b) ASPR 1-337 also cites other circumstances in which procurements for items or systems not requiring DSARC approval shall be reviewed for possible application of Should Cost studies. The following additional policy is established concerning use of Should Cost reviews in the Navy:

(1) All planned and existing Acquisition Category II programs as defined in OPNAVINST. 5000.42A that are sole source, with significant future production should be reviewed for applicability of a Should Cost review. This does not preclude use of Should Cost on other programs as deemed appropriate by the Systems Commands.

(2) Procurement Plans for programs requiring DSARC approval and other programs meeting the criteria in (b)(1) above shall contain a discussion of the application of Should Cost studies prior to approval by MAT 02.

(c) Each SYSCOM will be responsible for staffing its own Should Cost study. The NAVPRO/SUPSHIP has certain responsibilities for monitoring contractor's cost (NPD 20-702.5) and DCAS/DCAA has certain responsibilities for providing field pricing support (ASPR 3-801.5). Should Cost reviews should be coordinated with these activities to ensure that the technical and professional expertise of the various units of NAVPRO/SUPSHIP and DCAS/DCAA are used without duplication of effort or skills.

(d) Upon completion of any Should Cost study, SYSCOMs are required to take positive action to ensure continuous monitoring by contract administration activities of contractors' actions to implement recommendations resulting from such studies.

Action Code in NAVSEA

CNM Policy Procurement Memorandum No. 55 is addressed to NAVSEA 02, in addition to four other Systems Commands. NAVSEA INST. 5400.1 assigns SEA 01G as the Command focal point for Should Cost.

SEA 01G Responsibilities

Up to the present, SEA 01G has not undertaken any Should Cost studies. In the most recent 1976-77 effort of a management review of Northern Ordnance Division, SEA 01G planned and organized the initial undertaking of the Financial and Program Management portion of the review. However, SEA 01G did not have enough available staff to accept the additional responsibility of performing as an active team member. This is acknowledge in a SEA 01 memo to SEA 02 of 11 November 1976. As a result of the SEA 01 memo, SEA 01G undertook the responsibility of culminating a formal Memorandum of Understanding with DCAA for the conduct of all Should Cost Studies in the Finanical/Management disciplines. This agreement was signed between the two Defense Agencies on 8 June 1977. This effectively provided relief to SEA 01G to actively participate in any forthcoming Should Cost Reviews.

Identification of Tasks Assigned to SEA 01G

SEA 01 has decided it could not provide manning for the Northern Ordnance Division Management Review and has requested that DCAA undertake the financial and program management position of the review.

The formal Memorandum of Understanding between NAVSEA and DCAA calls for DCAA to be available for similar roles in all future Should Cost Studies.

Progress on Tasks

The DCAA is now supporting the SEA 02 efforts in Should Cost reviews as stipulated in the Memorandum of Understanding.

Estimated Time Spent Last Two Years

The current rate of effort by SEA 01G has been about six man-months per year. Based on the Army's experience on Should Cost studies, SEA 01G anticipates that NAVSEA future study requirements might be as high as 13 to 17 major weapon systems and/or shipbuilding contracts each year.

It is the opinion of SEA 01G that there is only a limited probability of undertaking Should Cost studies of major shipbuilding contracts. Most of the contracting officer's Should Cost effort is presently being directed toward the analysis of costs during contract negotiations,

rather than a major review of the operation and management of the contractor. Navy presently emphasizes routine reviews of contractors' cost proposals and operations as being effective and useful to procurement activities. However, Should Cost becomes most effective on large production run procurements, but considerably less effective for limited runs of large complex ships with intensive labor input.

In the area of GFE, current indications are that a substantial number of procurements will require Should Cost Studies. The financial and management review at Northern Ordnance Division was originally estimated to require nine people for three months and a more detailed review would take five months. Actually, due to limited NAVSEA staffing, only a limited review was performed with the assistance of an outside contractor. Four to five men were involved intermittently over a period of three months and the Should Cost draft report has been completed.

Impact on Other Functions

Implementation of Should Cost studies by SEA 01G as the focal point, could have significant effects on its cost estimating and analysis functions.

Benefits to Navy Budget or Manpower

The only documented savings the Navy has is on a Should Cost study done at Pratt and Whitney in 1968. The Navy spent $300 thousand and

identified a possible savings of $105 million on a potential contract value of $1.5 billion.

Discussion

During the past few years, the Navy has put little effort into Should Cost. A GAO letter of 17 January 1974 to OSD questioned the Navy's lack of uniformity in the application of Should Cost efforts. Then in June 1974, MAT 02 issued formal criteria for studies within all Navy SYSCOMS. Later, in response to GAO, ASD (I&L) indicated that Should Cost would be required for all DSARC programs. This in turn was implemented by CNM PPM-55 of 15 December 1976, requiring a Should Cost study on all DSARC programs or a contracting officer's determination as to why a Should Cost review is not justified.

Since this is now mandatory, resources must be developed. SEA 01, as the Command focal point for Should Cost, sent a Memorandum of 11 November 1976 to SEA 02 which discusses its inability to participate in a management (Should Cost) review at Northern Ordnance Division of F.M.C. It was suggested that DCAA, in its responsibility under ASPR 3-801.2 and 3-809, perform the financial and management portion of the Northern review.

Under the terms of the Memorandum of Understanding between DCAA and NAVSEA (prepared by SEA 01), the DCAA would participate in a Should Cost government team and be responsible for audit/pricing functions in compliance with audit requirements of ASPR 3-809. Under this procedure, NAV-

SEA would be responsible for staffing each Should Cost study, other than for the role performed by DCAA. NAVSEA does not currently have the depth of operations and engineering staff it can divert to this effort. Up to the present, SEA 01G has not participated to any extent in Should Cost studies due to staff deficiencies.

Since SEA 01G is still the Command program co-ordinator for Should Cost, it has begun to investigate the possibility of developing an instruction course for potential Should Cost programs. SEA 01G states it is now in the process of identifying potential sources and funds for the development of a Should Cost training and organization program.

Findings

Should Cost studies must be considered under ASPR 1-337. Not every DSARC or other major program will require a Should Cost study if demonstrated otherwise by the Contracting Officer. Notwithstanding, some Should Cost studies will be required especially for GFM and NAVSEA must have resources to undertake them when required. By the very nature of the process, Should Cost is effective for large production runs of GFM etc. but much less effective for evaluating shipyards. Analysis of cost during negotiations is considered the most effective means of assuring a fair price for ship construction contracts.

As an analytical process in which cost estimating and cost analysis is only one of many required skills, consideration should be given to assigning the Command's focal point for Should Cost outside the purview of SEA 01G. A suggested focal point would be NAVSEA 07, the Industrial and Facility Management Directorate.

The following alternative methods of conducting Should Cost studies may be considered:

- By DCAA performing the audit/pricing and by the Defense Contract Administrative Services performing the technical capability evaluation, with both groups under the leadership and coordination of a NAVSEA assigned study director, supplemented by other NAVSEA staff as required.
- By a basic study group established in NAVSEA, supplemented by a selected staff and/or consultants as required.
- By a consultant firm hired by the government
- By contractor personnel
- By a private consultant firm hired by the contractor

The establishment of special groups within NAVSEA to perform Should Cost studies will require the assignment of qualified staff, either as a permanent group or through assignments as required from other Codes with the Command.

12. ECONOMIC ANALYSIS

Definition

Economic Analysis is a formal, structured, systematic approach to the problem of choosing how to employ scarce resources and an investigation of the full implications of achieving a given objective in the most efficient and effective manner.

Purpose

Economic Analysis is one of several aids to management to assist in the decision-making process. It is required as budget back-up material, when the primary justification for the item is to save money. For example, a "lease versus purchase" economic analysis will be prepared whenever lease or purchase decisions are viable alternatives for a budget item.

As an analytic technique, the procedure investigates the economic worth of weapons and support systems, force levels and other programs/projects by assessing the implicit effectiveness (benefits) and resources (costs) of various alternative approaches that will meet the stated program objectives. The benefits and other output measures are identified, in conjunction with the costs associated with the postulated alternative programs. The sensitivity of each alternative to its key assumptions and variables is investigated to permit trade-offs between alternatives and a recommendation as to the alternative(s) having

the best cost effectiveness.

Economic Analysis, while utilizing "Life Cycle Costs", is a separate and distinct structured approach by quantifying and comparing "Benefits" as well as "Costs" and comparing alternative ways of accomplishing a specific objective.

Principal Directives

The Office of Management and Budget (OMB) Circular No. A-109 of April 5, 1976 establishes policies to be followed by Executive Branch Agencies in the acquisition of major systems. It requires that economic analyses be performed as one step in the management of Government procurement. This is construed to require an economic analysis for each DSARC project; however, some Project Managers frequently hire outside consultants to prepare the formal Economic Analyses for their projects.

The Department of Defense Instruction (DOD INST) 7041.3 of October 18, 1972 on Economic Analysis and Program Evaluation for Resource Management outlines policy guidance and establishes a framework for consistent application of:

- Economic analysis on proposed programs, projects and activities, and
- Program evaluation on on-going activities

SECNAVINST 7000.14A of 14 March 1973 refers to DOD INST 7041.3 of October 18, 1972 and states that, normally, analyses will be prepared at the organizational level at which a request for resources originates.

Action Code in NAVSEA

NAVSEA 5400.1 establishes NAVSEA 01G as providing a Command focal point for Economic Analysis.

SEA 01G Responsibilities

The Cost Analysis Branch, SEA 01G2, acts as the Command focal point for Economic Analysis (except for Management Information System (MIS) economic analysis). As the focal point, it provides staff assistance and advice to all areas of the Command and to the field activities including an independent appraisal of projects in the early conceptual stage. The Branch does not perform all of the Economic Analyses required.

Some Program Managers also perform economic analysis studies, others subcontract the task and others may request assistance or guidance from SEA 01G2 as necessary. OPNAV 96D also has the capability to undertake cost studies and economic analyses.

Identification of Tasks Assigned to SEA 01G

Economic Analyses are essentially undertaken or directed by the Head of the Systems Analysis Section, SEA 01G21, who is presently not provided with any staff and performs this function along with many other separate functions. The studies to date cover a wide range of subjects.

For example, in 1973, SEA 01G21 participated in a DE 1052 Engine Room Automation program where the Program Manager's techniques were validated. This was a two month project, requiring about one man-month of effort.

In the same year, NAVCOMPT directed NAVSEA Program Manager and SEA 01G to undertake a study on an economic comparison of commercial built and chartered tugs, commercial tug services and Navy built and operated tugs. Under the direction of SEA 01G21, the work was completed by a Naval Reserve Unit in six months, with SEA 01G21 participation of one day per week for six months.

A comparison of nuclear versus conventional fuel study was originally conducted by SEA 01G21 in 1973 based on a direct request from the Senate Armed Services Committee which required two man-months of effort. This is updated on an annual basis.

In 1976 - 1977 a study was conducted on the use of a shipboard

communication data multiplex system versus conventional wiring to justify possible installation in CSGN. The project was directed by SEA 01G21 and the team consisted of personnal from SEA 01G, NAVSEC, Project Engineers and contractor personnel. In this case NAVSEA 06 validated the contractor's assumptions. The time devoted by SEA 01G21 was 25 man-days.

Progress On Tasks

There are no tasks outstanding at this time, (April 1977).

Estimated Time Spent Past Two Years:

SEA 01G21 conducts an average of three economic analysis studies per year with an input of one man-month per study. In addition, the section head is consulted on economic analysis procedures and also conducts courses on the economic analysis process. Thus, about 35 to 40 percent of his total working time is devoted to these studies. With the increase emphasis being given to costs and quests for alternatives, it can reasonably be expected there will be an increase in demands for this function.

Impact On Other Functions

With a limited staff and other responsibilities in this one section, such as should cost, technical cost analysis reviews, life cycle costs, the design and management of computer programs for cost analysis and cost estimating, and maintenance of cost data banks with ADP, etc., every assigned project

must vie with others. Hence, it becomes necessary to establish priorities. There is danger in a situation such as this that while the functions are performed they can represent minimal efforts, none of which may be sufficiently done for the purpose intended.

Benefits to Navy Budget or Manpower

All of the aforementioned economic analysis studies have value, and in certain instances, required in the formal decision-making process. None of these studies, however, are directly related to the basic acquisition cost estimating process and could be assigned to another organization.

Discussion

The various cited economic analyses conducted within SEA 01G have value in the decision-making process. The studies are frequently undertaken on a time-available basis and are also conducted by others such as OPNAV 96D or Program Managers working under the optional direction or guidance of SEA 01G21. Project Managers or DSARC projects frequently utilize outside consultants to evaluate projects. The requirements to conduct economic analyses are indicated through SECNAVINST. 7000.14B. Internal SEA 01G priorities establish the work actually accomplished.

SEA 01G has a major role but is only one part in the mainstream of conducting economic analyses, with a strong role by the specific Section Head in knowing and teaching the process. There is no back-up capability and new hires, essentially trainees, will not be capable of performing in the Command role. Many factors other than cost estimating and cost analysis are involved in the process. It, therefore, follows that economic analysis could be conducted in one or more of the following manners:

- Retain in SEA 01G but provide an individual with this function as a sole responsibility
- Place in new centralized special study unit within NAVSEA, with SEA 01G participation only as required
- Utilize outside consultants

Findings

Regardless of where the final responsibility for conducting and monitoring Economic Analysis is placed, at least one full-time staff member will be required, who in turn will be supported by necessary staff assigned from other Codes.

13. ECONOMIC FORECASTING

Definition

Economic Forecasting relates to the development of labor and material cost trends and indices.

Purpose

The rapid and often unpredictable increase in labor and material costs over the past several years in the shipbuilding and Naval Systems industries has made it imperative to develop the best possible information on these cost projections. Estimates and budgets are developed well in advance of the actual contracting dates. In addition, contract completions are frequently delayed. Thus, forcasting of inflationary trends and anticipated contract escalations often lead to under-estimating and budgeting for contract escalation. Ships under construction in earlier programs are showing escalation several times greater than had been forecast.

Principal Directives

The problem of economic forecasting has been of great concern to the Navy over several years. NAVCOMPT Notice 7111 of 29 August 1969 provided guidance for FY 1970 and 1971 budget submissions with instruction that it should include future price changes in labor and material costs.

Action Code in NAVSEA

NAVSEA 5400.1 establishes the responsibilities for developing economic analyses and forecasting with SEA 01G acting as the Command focal point. It requires the developing BLS labor and material indices for the shipbuilding industry and then preparing forecasts, herein identified as Economic Forecasting, which are utilized in the preparation of cost estimates and budgets.

The CNA study in "Influence of Forecasts of Prices and Market Conditions on Estimating and Pricing of Ships" was completed February 3, 1969 as input into the SCN Pricing and Cost Control Study of April 1969. CNA indicated that economic forecasting will always container errors, but that a sophisticated technique is likely to improve the credibility of NAVSHIPS (now NAVSEA) estimates. It would also increase credibility and documentation of the SCN ship estimating process. CNA further indicated that NAVSHIPS 05F (now NAVSEA 01G) has more information with respect to shipbuilding economics than any other place in the Government. It suggested a staff member be assigned full time to economic forecasting.

SEA 01G Responsibilities

Economic Forecasting is the responsibility of SEA 01G. This group has extensive wage information from 16 shipyards reporting through BLS. It also maintains records of management-labor agreements involving shipyard unions

throughout the U.S. This data bank is supplemented by industry and Navy evaluations and gives a sound basis for projecting labor escalation costs.

Material forecasting has also been accomplished in-house, however, Data Resources, Inc. (DRI) has recently been contracted to provide material forecasting models and data banks to assist SEA 01G in developing material escalation projections. Steel price increases, EPA and OSHA costs, steel imports, mill capacities and expansion plans and oil price increases are considered.

The data bank within SEA 01G, industry data sources and the assistance of DRI will strengthen credibility of the development of material escalation projections.

The aforementioned escalation projections relate to shipbuilding only. The Assistant Secretary of the Navy Financial Management Planning Group Inflation Study of 11 April 1975 made a cogent recommendation:

> "A set of DON Escalation Price Indices be developed which are directly relatable to the specific weapon systems, goods, and services pruchased by the DON."

At present NAVSEA is the only SYSCOM that prepared an economic forecast for use in the budgeting process. All others use projected indices provided by the office of Secretary of Defense. These NAVSEA forecasts are currently approved by OSD and become the official projection issued for the SCN appropriation.

Wages and material costs and trends vary from industry to industry. In addition, the BLS steel shipbuilding indices do not apply to weapon and ship system estimating. SEA 01G advises that other estimating commitments have prevented the development of specific indices for WPN (Weapons Procurement, Navy) and OPN (Other Procurement, Navy). It has been demonstrated that these are subjected to special cost considerations. The staff estimates that it will take about two years to establish a proper program, after which it will require about eight man-months per year of effort to maintain. The assistance of a private contractor to establish the program will reduce the need for additional staff services.

Estimated Time Spent Last Two Years

It is estimated that two man-years of effort is presently being expended in the evaluation work and computer input/output time on the economic forecasting function in SEA 01G.

Discussion

Material and labor inflation has been demonstrated to be the primary cost driver in naval acquisition programs during the past few years. Thus, credible economic forecasts must be made to establish anticipated inflation and escalation over the contracting period for both shipbuilding and GFM.

The difficulty of projecting inflation is demonstrated through a recent comparison of the performance of three major professional econometric forecasters. This indicates an average forecast of actual price increase error, over a four year period, to be approximately 80 percent. The 1973 and 1974 periods of high inflation were the principal contributors to this high average error, with 1975 and 1976 errors ranging from 21 to 47 percent.

The current development of labor cost projections and indices by SEA 01G is considered good and well documented. Similarly development of material cost projections and indices by SEA 01G, supplemented by DRI support is also considered good. The strengthening of SEA 01G data bank for material is suggested as follows:

- Routine and prompt monthly cost information should be obtained from ship yards
- A more accurate forecast of delay in construction of each ship type should be developed
- Develop and include specific labor and material information of GFM

It must be recognized that the most carefully documented labor and material forecasts will be affected by unanticipated events.

Findings

The ability of SEA 01G to develop labor and material cost projections for shipbuilding is considered fair. It is suggested that the data banks for material be strengthened as follows:

- Periodic material cost trend information should be obtained from ship yards and manufacturers
- Develop adequate data banks and information on GFM (both WPN and OPN) to permit projecting special price indices for major systems and goods not susceptible to normal BLS indices.

It will be necessary to supplement staff and/or utilize services of private contractors to develop specific indices.

14. LIFE CYCLE COSTING

Definition

Life Cycle Costing (LCC) is an acquisition or procurement technique which considers research and development, investment, operating and support, and other costs of ownership in the decision-making process and in selected cases for construction or manufocture of weapon systems, equipment , hardware, and related support.

Purpose

The objectives of Life Cycle Costing are:

- To develop cost data for the purpose of evaluating management, engineering, and logistics trade-offs.
- To provide a basis for estimating the total program costs and funding requirements.
- To provide an up-to-date tally summarizing all actual and projected investment and operating costs associated with logistic support over its full operational life.
- To seek the lowest total cost of ownership in system/equipment acquisitions.

Life Cycle Costing techniques are to be applied to as many acquisitions as possible.

Principal Directives

The concept of Life Cycle Costing has been used within DOD and its Military Commands for several years. The "Preliminary Report on SHIPS 05F2

(now SEA 01G) Staffing Requirements" dated 30 September 1968, indicates that no one in the Navy was doing LCC on a systematic basis. When accomplished, a significant part of the acquisition cost input and analysis was provided by SHIPS 05F2 and the report indicated that it appeared this group was best qualified to provide cost model input and interpretive analysis of output regarding costs.

NAVSHIPINST 5432.1B C4-14 of 23 March 1971 established the responsibility of SHIPS 016 (now SEA 01G) to perform ship life cycle cost estimating for the Command as required.

Recently, greater emphasis has been placed on Life Cycle Costing. In a memorandum of February 28, 1975 Deputy Secretary of Defense, W.P. Clements, Jr., expressed concern with the continuing growth of the fraction of total DOD resources needed to operate and support weapons and the decline in funds for new weapons systems. He stated that DOD must have the dual objectives of reducing the fraction of the outyear budget allocated to weapon O&S costs while at the same time maintaining operational readiness. Secretary of Navy, J. William Middendorf II, responded in his memorandum of 14 July 1976 to Deputy Secretary of Defense Clements indicating near-term actions were being directed to control O&S costs. One of the principal points was to require that reasonable tradeoffs between O&S costs and acquisition costs be considered at DSARC/DNSARC presentations with the aim of reducing overall system (life cycle) costs. A complementary and parallel effort was

the establishment of an operating and support (O&S) cost data base. This was accomplished via implementation of the recommendations of the Visibility and Management of Operating and Support Cost (VAMOSC) Ship Study Group. However, current efforts are geared only to collecting data, not forecasting O&S cost data.

A memorandum from SEA 01 of 8 April 1975 to SEA 09B outlines the functional responsibility of SEA 01G to provide a Command focal point for Life Cycle Costing. NAVMAT Memorandum 0422/DC of 16 February 1977 requests the various Commands and Activities to review and evaluate the "Naval Material Command Life Cycle Cost Guide for Major Weapons Systems" of 1 January 1977. The evaluation period was to conclude on 2 May 1977. Office of Budget and Management Circular A109 requires LCC studies for all major systems acquisitions.

Action Code In NAVSEA

SEA 01G has the overall responsibility to provide the Command focal point for LCC studies.

SEA 01G Responsibilities

The responsibility of actually conducting LCC studies is placed in the Cost Analysis Branch (SEA 01G2). This group plans and develops programs, policies and procedures to enable cost analysis for shipbuilding programs to be

integrated with data provided by the acquisition cost estimator for Life Cycle Cost analyses. It also validates and assesses the effectiveness of NAVSEA and subordinate activities in Life Cycle Cost requirements.

Identification Of Tasks Assigned To SEA 01G

Life Cycle Costing assignments are performed by one staff member who is the head of Systems Analysis Section (SEA 01G21), which has no other analysts as staff support. This individual is also acting head of Policy, Procedures and Review Section (SEA 01G23) which has one analyst. These sections are part of the Analysis Branch (SEA 01G2). (See Figure D.2 for organization and staffing.)

Most of the staff member's input in LCC studies is in the form of guidance to other groups who actually perform the work, i.e., a vertical launch system. He is a member of NAVMAT's LCC implementation group. He has also participated in LCC studies on equipment such as SPS-49 Radar which was undertaken by private contractor and the shipboard use of multiplex cable for communication systems.

Progress On Tasks

Limited staff precludes much direct involvement, other than offering guidance on methodology and cost input. The overall work effort is currently

at a slower pace, however it could again increase in response to SYSCOM requests.

Estimated Time Spent Past Two Years

Approximately 20 to 30 percent of one staff member's time (say three man-months) is devoted annually to LCC.

Impact On Other Functions

The present LCC workload being undertaken by a limited staff, has considerable affect on other responsibilities assigned to the Systems Analysis, and Policy, Procedures and Review Sections.

Benefits to Navy Budget Or Manpower

Life Cycle Costing is an important tool in establishing programs and decision making. With proper application, LCC studies should result in either cost savings, more units per budget dollar, or more effective weapon systems.

Discussion

The "Life Cycle Cost Findings and Recommendations" of April 1976 prepared for the Assistant Secretary of Defense by an NSIA AdHoc Committee covers in detail the findings and recommendations necessary to meet DOD requirements.

The value of LCC studies and the decision of DOD to use this technique for all acquisition programs is evident. The process considers many cost factors such as:

- Research and Development
- Engineering
- Acquisition
- Facilities
- Training
- Operation
- Support
- Management

The role of SEA 01G is limited to acquisition cost, with LCC heavily influenced by integrated logistic support costs. While SEA 01G has a staff member capable of developing and guiding these programs, the responsibility of the end product could properly be transferred to another NAVSEA group such as SEA 04, Fleet Support Directorate, who has considerable input. SEA 01G would then only participate with acquisition cost input or act as a consultant as required.

Findings

Life Cycle Costing is required in the development of all DOD major acquisition programs as a means of reducing overall system costs. Since LCC is heavily influenced by integrated logistic support costs and since SEA 01G participation is basically limited to acquisition costs, it would be logical to

transfer the Command's focal point for LCC from SEA 01G to another NAV-SEA group, such as SEA 04, Fleet Support Directorate. Then, SEA 01G will only be responsible for system acquisition costs.

15. DESIGN TO COST

Definition

In general terms, Design to Cost (DTC) means selecting a unit cost goal and developing a product with that goal as the principal cost parameter. This DTC can apply to "fly away", "life cycle", "unit production" or some other costs. [The NAVMAT Command refers to DTC as the development and design of equipment with full consideration and control of all elements of future costs of ownership (acquisition, operating, support) which are subject to influence by the technical (design) characteristics of equipment.]

Purpose

Projected defense budget levels and rising costs of acquiring, operating and supporting defense systems and equipment have created the need to make cost a major design parameter. Design to Cost provides a cost discipline to be used throughout the development and acquisition of systems or equipment.

The DTC procedures apply to the total ship system, to ship subsystems which are developmental in nature, and to ship support subsystems and equipments which are state-of-art and procured routinely.

Principal Directives

The Design-to-Cost, as a means of optimum cost acquisition, has been required in DOD over several years. SECNAVINST 5000.1 of 13 March 1972 governs the acquisition of systems within DON. The Deputy Secretary of Defense Memorandum for Secretaries of the Military Departments of 24 May 1974 extended the management principles to subsystems as well as lower level systems. NAVSEA INST 9060.2 sets forth a DTC Guide for Ship Acquisition and encloses Design-to-Cost Guide for Naval Ships of the same date.

DOD Directive 5000.28 of 23 May 1975 establishes the policy that DTC will be implemented in all DOD development programs except for the relatively small number where the management principles of DTC are not suitable. CNM Procurement Policy Memorandum (PPM) Number 48 of October 4, 1976 outlines the various stages of system development and application of DTC. It directs that DTC goals be established at the earliest practical point in the development process.*

The major phases of acquisition are:

* DTC will generally not apply to basic research, major national security programs in which performance, reliability and/or schedule take precedence over cost as a primary consideration, or systems that have basically been designed.

- Conceptual Phase where alternative concepts for satisfying operational requirements are studied with the objective of selecting the most promising for further development. Formal DTC goals are not normally practical in this phase, however, initial DTC goals for overall planning should be used as appropriate.

- Validation (Advanced Development) Phase will normally include the design, fabrication and testing of one or more prototypes of the equipment. This is also a critical phase in the successful execution of DTC since normally the basic ship design configuration is fixed at this time.

- Full Scale (Engineering) Development Phase will normally include the design, manufacture and testing of production configuration units. All DTC goals are to be established by the start of this phase and should be specified in procurement plans.

- Production Phase normally includes the manufacture of the operational items. The design part of DTC should be essentially complete; however, this phase will include the measurement of production costs to determine if unit cost DTC goals are being met.

Action Code In NAVSEA

NAVSEAINST 9060.2 directs action as:

- SHAPMS will provide for the design and acquisition of naval ships within cost constraints and works with other Commands and groups in DTC ship systems.

- Cost Estimating And Analysis Division will prepare estimates as requested by SHAPM, propose cost influencing factors for any adjustment of DTC constraint and estimates to a base year, and continually upgrade its cost estimating expertise.

- NAVSEC will perform assigned ship design, perform cost versus characteristic and performance trade-offs, and establish

the interface and ship support requirements used to track impact of subsystems on the ship as a system.

- Participating Managers will provide for the acquisition of assigned ship subsystems (i.e., propulsion units, weapons, etc.) within established cost constraints in accordance with Ship Project Directives, these DTC principles, and within the previously agreed to time schedule and design envelope.

CHNAVMAT Memorandum (Memo 277-77) of 24 May 1977 to SYSCOMs addresses policy on Design-to-Life Cycle Cost (DTLCC) and establishes that Systems Commanders full participation in DTLCC programs and also identify in their Command a central point of contact and responsibility in these efforts.

It is understood that NAVSEA 0745 has been the focal point for the Command DTC programs; however, the position of the individual holding this responsibility has been declared surplus. Hence, it is necessary to reassign this focal point responsibility elsewhere in the Command.

SEA 01G Responsibilities

Under NAVSEA INST 9060.2 of 24 July 1975, SEA 01G is directed to prepare the necessary cost estimates as requested by the SHAPM for DTC studies. While SEA 01G is not the focal point, it does furnish cost data to NAVSEC and participates as a member of the DTC group in performing the estimating function. These estimates may be modified or adjusted by the SHAPM.

Identification Of Tasks Assigned To SEA 01G

DTC generally applies to new ship or system concepts. Established ship types or follow-on programs usually do not justify or require DTC studies. On the average, one or two new designs are developed each year. SEA 01G is capable of undertaking broad trade-off studies on a seven group weight system, however, cost trade-offs frequently involve discreet item or system changes which require a lower level of technical information and cost breakdown (frequently unavailalbe) in either SEA 01G or NAVSEC. Typical design changes could be the installation of stabilizer fins, steam versus gas turbine plants, substitution of weapon systems and others. SEA 01G does not have a satisfactory lower level of cost breakdowns or sufficient data banks to routinely undertake such details.

NAVSEC is also limited in its ability to develop detailed specifications, installation sketches and weights in a timely manner to be used by SEA 01G for each discreet design change. Hence, the cost aspect of DTC studies becomes rather broad based, which is satisfactory for preliminary ship or system concepts, but unsuitable as the design gets further along in the advanced development phase.

Progress On Tasks

SEA 01G has been meeting its obligations to assist in DTC studies.

Estimated Time Spent Past Two Years

A yearly average of four man-months is devoted to DTC work.

Impact On Other Functions

Depending upon the number of new DTC studies being developed, there could occasionally be an impact on the ability to prepare various budget and other acquisition estimates.

Discussion

The present budget problems and the cost consciousness of the Administration, Congress, Department of Defense and the country as a whole make it apparent that Design-to-Cost is a mandatory tool in military acquisitions. Thus, NAVSEA and the other Commands must be prepared to undertake the necessary cost trade-off and iterative cost studies.

Findings

NAVSEA is presently losing its focal point to coordinate and plan DTC studies and whether the assignment will ultimately remain in SEA 0745 is not known. As an alternative, the responsibility could be logically assigned to NAVSEC in view of their major involvement in the design development and cost versus ship characteristic and performance trade-off studies. The other involved groups, namely SHAPM, SEA 01G and the Participating Managers, would continue their present role and responsibilities.

16. COST MODELING

Definition

Cost Modeling is an estimating tool wherein a set of mathematical relationships is arranged in a systematic sequence to formulate a cost methodology in which outputs (cost estimates) are derived from inputs (descriptions of equipment, organization or system). Cost models can vary from a simple one-formula model to an extremely complex model involving hundreds of calculations generally using a computer.

Purpose

The object of a cost model is to translate historical or current cost data from possible different systems or equipment into an estimate of future costs for the system or equipment being costed. The projections are usually calculated by cost estimating relationships (CERs), factors, engineering estimates, or other types of estimates, where applicable. The consistency of response inherent in cost models enables the analyst to make comparisons among alternatives. The analyst can be sure that identical inputs are treated alike and that the differences in cost estimates are based on differences in basic input parameters.

Principal Directives

Cost modeling is a methodology of developing cost estimates, whether

it is accomplished with a hand calculator or whether a computor program is utilized. There are no specific Navy directives that formally establishes a requirement for cost modeling, however this method is presently being used within NAVSEA as a labor saving estimating tool.

Action Code in NAVSEA

There is no focal point of responsibility within NAVSEA for Cost Modeling. The Naval Ship Engineering Center (NAVSEC) has developed computerized cost models which utilize cost information from SEA 01G. There are three types of models commonly used, namely:

- Acquisition models which look at acquisition costs as a function of design parameters. These are developed for almost all ships where design trade-off studies are being done, also for individual items of equipment.
- Models that compute total life cycle operating and support costs for a particular ship. These are used for trade-off studies on projects such as DG AEGIS, Sea Control Ship, PF (FFG) and others. Sometimes total LCC analysis is done by combining these two Programs.
- Integrated LCC models which look at all elements of cost at one time, such as for Trident submarines.

The Division of Cost Estimating and Analysis (SEA 01G) also utilizes cost models for use in preparing ship and ship systems estimates and budgets as hereinafter explained.

SEA 01G Responsibilities

NAVSEAINST 5400.1 assigns SEA01G as the Commands focal point for all cost estimates. It also directs that the Division provide ADP system design and management to support the total cost analysis/cost estimating function and to maintain a centralized ship cost data bank.

This support is being provided. Many of the computer models are of the accumulative type which use Cost Estimating Relationships (CER) and allow input variations. This ensures uniformity and accuracy of estimate outputs. Special programs to suit specific estimating requirements are also developed. In addition, SEA 01G has an option under it's major computerized Cost Model for developing End Cost Analyses (cost to government) for budgets. The Cost Modeling capabilities have not yet been extended to permit unit estimating, other than having developed a data base for sonar and non-ship electronic equipment.

Identification of Tasks Assigned to SEA 01G

The Cost Modeling program is geared to assist the estimators in performing specific tasks.

Progress On Tasks

With the presently limited scope of the computer programs, the Cost Analysis Branch in SEA 01G is able to meet the estimating staff's requirements.

Estimated Time Spent Past Two Years

Approximately eight man-months of effort was required to develop the present aforementioned computer programs and the equivalent of about one man-week of effort is required annually from SEA 01G for general staff assistance to SEA 01G users.

In order to develop a more analytical use of Cost Estimating Relationships (CERs) and to permit unit estimating which requires the input of detailed bid back-up, returned cost data, and other cost details, it is anticipated that one full-time man would be required. This program might alternatively be accomplished through a private contractor at an approximate cost of $150,000 over two years, and after completion at about $25-50,000 yearly for updating and maintaining the programs.

As an illustration of the number of cost estimates developed through the use of computer models, approximately 250 separate estimates of the total program costs were prepared in the design development of the SCS ship. During the preliminary design of the new class of AO ships, fewer estimates were made but they were more sensitive to detail design characteristics.

Impact On Other Functions

Under present effort level, there is no impact on SEA 01G's other functions. An in-depth implementation of a broader computer program, however, would improve the effectiveness at the Division.

Computer programs combined with adequate and current data banks can save considerable estimating time, expecially when compared to the usual manner where the estimator maintains his own data bank or has only limited information with which to work.

Benefits To Navy Budget Or Manpower

The existing cost modeling programs are of value to the estimator in providing arithmetical accuracy and consistency in the end product. An expanded cost modeling effort to provide a current and more useful data bank would enhance the estimating capability.

Discussion

Cost modeling, as practiced by NAVSEC, is an off-shoot of programs initially prepared to develop ship weights for engineering and also for estimating purposes by both SEA 01G and NAVSEC. These programs, which are reasonably extensive, now undertake cost models in terms of cost trade-off and Design-to-Cost studies.

Cost modeling as practiced by SEA 01G, the Command's focal point for estimating, is limited in scope. The availability of bid back-up costs, returned costs, and other cost data which is limited at present, could form the base of extended computer programs. This would provide a better base and broaden estimating capabilities.

Findings

The extension of SEA 01G cost modeling activities to provide a dynamic data base would benefit the cost estimating process. Consideration should be given to adapting and amplifying the NAVSEC program to include unit costing capability.

17. OVERHEAD ANALYSIS

Definition

Overhead Analysis is the intensive review of current overhead (or indirect) cost elements, i.e., labor related variable costs, semi-variable costs, and fixed costs, as a means of predicting possible changes in shipyard overhead for use in future cost estimates.

Purpose

Over the past ten years, the overheads in the shipbuilding industry have risen from a range of 60 to 80 percent of direct labor dollars to a range of 90 to 120 percent. Thus, changes in overhead do have a significant effect on an estimate. It is necessary to review and update the effect that each of the many overhead cost drivers have on the total overhead assigned to each acquisition project.

The composition of the principal overhead elements, each sub-element of which is composed of many detailed items, is as follows:

- Labor Related Variable Costs
  - Indirect labor
  - Maintenance labor, bid and proposal expense, and R&D
  - Fringes and benefits

- **Semi-Variable Costs**

  - Maintenance and repair material
  - Energy costs
  - Information processing and home office expenses

- Fixed Costs

  - Depreciation and others
  - Fixed repairs
  - General overhead

The Overhead Analysis process requires the collection of data, sensitivity analysis with related models, understanding of economic changes and trends, and effects of these changes on the many afore listed cost components. The effort requires an understanding of various accounting systems and a cooperative effort of the contractors, DCAA and others to ensure access to the required information. This is not a duplication of DCAA's responsibilities on existing contracts, but rather it provides a base for budgeting cost estimates well in advance of the normal responsibilities of DCAA.

Principal Directives

Overhead Analysis is not explicitly addressed in any directive, but is encompassed by directives concerning cost analyses. SECNAVINST. 5000.2 requires that detailed cost estimates shall be supplemented by appropriate economic analysis. OPNAVINST. 7000.11 requires submittal of CCDR, part of which information is overhead data.

A joint effort of DOD (I&L) and National Aeronautics and Space Administration (NASA) resulted in development of a "Guide for Monitoring Contractors Indirect Cost" of 3 July 1974 (Navy P-4330). This is in considerable greater depth than "Overhead Analysis" as defined in this paper since it is essentially used as a guide in managing indirect costs and thus control their growth. Effort to monitor overhead on the basis of this guide has been poorly received by the contractors and it has never been implemented. This guide for controlling overhead costs is somewhat similar to a Should Cost program for shipbuilding or other major acquisitions.

Action Code in NAVSEA

NAVSEA INST. 5400.1 assigns SEA 01G as the central cost estimating action code.

SEA 01G Responsibilities

This Code is responsible to develop and maintain current overhead information and preparing projections based on the present economic trends. The data used in overhead analyses is usually obtained from bids, audit reports, CPRs, field activities and others. The overhead analysis prepared by SEA 01G is primarily for budgeting and estimating purposes. The current practice at contract award time is for the contract negotiator, SEA 022, to completely depend upon the evaluation of DCAA as to the reasonability and propriety of the overhead in the proposals.

Identification of Tasks Assigned to SEA 01G

Each estimate includes a cost factor for overhead which is composed of many subfactors. Each of these rapidly change under the influence of varying workloads, union negotiations, fuel costs, taxes, capital investment and other factors. Methods of establishing overheads also differ by yard, hence an average national or regional shipyard overhead factor may fall far from the overhead actually allowed in a specific shipbuilding contract. Thus, overhead is a very fluid and important estimating and budgeting consideration.

Each of the many overhead factors must be carefully monitored, analyzed and projected for each proposed budget and contract. The overhead rate will vary throughout the entire contract. SEA 01G proposes to create an in-house computer data base of relevant and current overhead data. This requires a better understanding of major shipyard accounting practices and also requires a better flow of detailed information from SupShips, DCAAs and contractors to SEA 01G. The proposed models will have capabilities with varying scenarios, such as manning requirements, effect on construction delays, and work backlogs.

Progress on Tasks

The development of improved overhead predictions is well under way. The establishment of an adequate flow of detailed overhead data must be assured and programmed.

Estimated Time Spent Past Two Years

In the last year, one staff member devoted about 40 percent of his time to conducting overhead analyses as a result of a concerted effort to analyze detailed data received from DCAA. This does not provide for the development of additional improved computer programs as planned.

Impact On Other Functions

The present level of effort in undertaking overhead analyses does not impact on the other cost analysis responsibilities. However, additional computer program development and data retrieval work would affect other cost analysis work in SEA 01G if additional staff is not made available.

Benefits To Navy Budget Or Manpower

The development, maintenance and availability of current overhead projections for the various major shipyards construction naval ships would assist in preparing credible estimates and budgets.

Discussion

Overhead with its many components has been demonstrated to be a major factor in the preparation of credible estimates. During the past ten years, overhead as a percentage of direct labor has risen on the average about 50 percent. Actual overhead dollars in one yard have risen about 74 percent

as compared to a 53 percent growth in labor dollars over the same ten year period.

The majority of overhead information presently received by SEA 01G is minimal in nature, usually a single number expressing the overhead of an on-going or proposed contract. Other information obtained by SEA 01G is obtained in an informal manner. Much of this limited data has revealed the fluid nature of overhead costs which emphasizes the need to develop necessary data banks to permit overhead projections for estimating and budgeting purposes.

SEA 01G has been using average, or most reasonable, overhead rates based on past bids adjusted for projected work loads in their estimates. Attempts have been made to utilize the very limited data from DCAA offices. The availability and analysis of detailed overhead breakdowns from a wider variety of shipyard sources would allow the development of overhead projections with greater confidence.

Findings

There is a need for NAVSEA to immediately develop additional sources of information covering detailed cost breakdowns and projections of shipyard overhead. This information should be placed into a data bank on a continuing basis and analyzed, preferably through the use of computer programs.

18. FIELD AUDIT

Definition

Field Audit is the review and evaluation of field activities relating to policies, procedures, methodology and capability to perform cost estimating. Typically, the Field Audit will be conducted in such organizations as naval shipyards and Supervisor of Shipbuilding offices.

Purpose

The purpose of these audits is to ensure that all field policies and procedures conform to the regulations and policies of NAVSEA; to ensure that the data base is valid for the application; to ensure that the estimating methodology is properly used; and to ensure there is adequate feedback to check the reasonableness of previously made estimates.

Principal Directives

NAVMATINST 7000.19A of 30 July 1976 directs that each SYSCOM responsible for major weapon system acquisition shall maintain a designated central cost analysis/estimating group capable of generating/certifying complete, consistent estimates for the development, investment and operation of weapon systems under his cognizance. It further states as policy, that within each Systems Command there shall be one focal point referred to as the Cost Analysis and Estimating Group (CAEG) which is responsible for cost estimating policy and guidance.

Action Code In NAVSEA

NAVSEA INST 5400.1 directs SEA 01G to conduct field audits.

SEA 01G Responsibilities

This Division is responsible for establishing procedures and policies for the development and documentation of estimates developed in the field. For example, one of the assignments is to monitor estimates developed by Planning and Engineering for Repair and Alteration (PERA) groups who plan and estimate overhauls and repairs of ships in naval shipyards. The Ship Logistic Managers (SLM), as well as SEA 04, are also involved in PERA activities.

The estimating techniques used by PERA closely resemble those used by commercial ship and repair yards except that with the advent of stabilized rates, the yard has little if any control over the rates charged to customers. This stabilized rate includes all incidental material needed to perform repair or alteration work; thus, the PERA's prime and only function is to develop the man-days required for the alteration or repair item. Work orders for each repair and alteration are developed, and detailed labor estimates are made of each work order. This differs from ship and ship system estimates developed by SEA 01G where the nine group system using ship weights and applying broad dollars per ton factors to these weights are used. Also, SEA 01G forecasts labor and overhead rates for private and naval shipyards plus GFM. Thus, Field Audits of PERAs would be in the areas of methodology, policies, and other factors related to man-day estimates.

Identification of Tasks Assigned to SEA 01G

Negligible field audit work has been undertaken by SEA 01G due to press of higher priority cost estimating work. One staff member recently participated with an Industrial and Facility Management Directorate (SEA 07) team sent to the Philadelphia Naval Shipyard.

Progress on Tasks

There are no Field Audits projects underway at this time.

Estimated Time Spent Past Two Years

Negligible.

Impact on Other Functions

Under present effort level, there is no impact on SEA 01G's other functions.

Benefits to Navy Budget or Manpower

If the responsibility would be implemented by SEA 01G, audits of PERA and other field groups estimating and budgeting capabilities would be established and documented.

Discussion

The responsibility of SEA 01G to conduct Field Audits is clear. It is also desirable to have a central cost-estimating and cost analysis responsibility within NAVSEA which establishes policy and broad procedures for both central and field activities. In the absence of having conducted full field audits, the benefits are unknown at this time.

Findings

This function is not being implimented at the present time to any significant degree.

19. SPECIALIZED PROGRAM/SOFTWARE COSTS

Definition

Specialized Program/Software Costs relate to estimates for specific areas of acquisition contract requirements that may or may not be hardware oriented. These may affect the basic estimates for hardware, material, manpower requirements, engineering and/or overhead. Examples of such costs are:

- System Engineering Disciplines
- Improved Test and Evaluation
- Project Management Costs
- Improved Combat Survivability
- Federal Regulations and Laws
- Safety Engineering
- Human Factor Engineering
- Standardization
- Quality Assurance
- Value Engineering Project Management
- Proposed Metrication
- Cost Schedule Control System
- Other Special Reports

Purpose

In order to budget for total program costs, all cost elements from conception thru delivery must be considered. Specialized Program Costs generally reflect Navy requirements which are inherently difficult to estimate due to the absence of ready measures to scope or quantify the cost impact. Due to the lack of definition, added complications, and manpower requirements the shipbuilders have objected to many of the requirements as was noted in the paper prepared by the Shipbuilders Council of American of October 22, 1974. Cost estimates prepared by industry for such requirements have had wide variances.

Within the shipbuilding program, costs referred to as System Engineering or "Ilities" were initiated with the Concept Formulation/Contract Definition process such as with the FDL, LHA and DD 963 programs.

Typical items included in Ship Systems Engineering are: Reliability and Maintainability, Safety Engineering, Design Work Study and Human Factor Engineering, Standardization, Integrated Logistic Support, Quality Assurance, Value Engineering, Project Management Support and Configuration Management. New program cost requirements now emphasized are Combat Weapon Systems, Survivability/Vulnerability, and Test and Evaluation. In addition, cost impacts are associated with programs such as Habitability, and the Cost Schedule Control System. The planned use of the Metric System is expected to incur additional costs and is an example of a new requirement that is difficult to define but its cost impact must be budgeted no matter how gross the estimate.

In addition to program cost elements which have been initiated by the Navy and DOD, are costs associated with Federal regulations and laws such as the Occupational Safety and Health Act (OSHA), increase in Social Security Benefits, impact of the Longshoremen's and Harbor Worker's Compensation Act, and Environmental Legislation. A discussion of the Economic Impact of Environmental Protection, Occupational Health and Safety and Workman's Compensation on the U.S. is included in the Report of the Commission on American Shipbuilding of October 1973.

Common to all the preceding requirements is increased costs and difficulty in accurately estimating. The costs for most of the Ship System Engineering Disciplines are paper end-products (both engineering and management systems) vice hardware, to produce a better product. These costs can impact the shipbuilders' or Government's administrative costs.

Principal Directives

MIL-STD-881 provides the work breakdown structures for Systems Engineering and supporting Project Management cost elements for all major defense material items. A NAVMAT pamphlet "Selected Aspects of Ships Engineering" dated May 1969 is a compilation of discussion papers which briefly describe and provide approximate cost factors. Typical Directives which also list requirements are as follows:

Testing and Evaluation	NAVSEAINST 3960.2
Combat Survivability	NAVSEAINST 5400.19
Reliability of Naval Material	NAVMATINST 3000.1
Cost Schedule Control System	DODINST 7000.2
Habitability	OPNAVINST 9330.5
Integrated Logistic System (ILS)	NAVSEAINST 4410.20
Metrication	DODINST 4120.18
Data Management	NAVSEAINST 4000.6

Action Code in NAVSEA

There is no central focal point assigned for the Ship System Engineering or other disciplines although most of the functions are within the SEA 04 and 06 Directorates. In organizational elements outside of NAVSEA the function is widely dispersed.

SEA 01G Responsibilities

As the centralized cost estimating group for shipbuilding and focal point for cost related functions, SEA 01G has the inherent responsibility to ensure all programs are fully costed.

Identification of Tasks Assigned to SEA 01G

Based on contract data for the three major Concept Formulation/ Contract Definition (CF/CD) programs, gross cost factors were developed to reflect costs associated with the Ship System Engineering Disciplines. The factors have not been fully applied to all new ship programs as no program approached the same magnitude of intensive effort as those which went thru the formal CF/CD process. In addition the new contracts have not required full identification of the costs associated with Ship Systems Engineering and therefore are inherently included in the material and labor cost factors used. Estimated costs for new program elements such as Test and Evaluation and Combat Survivability are obtained from the respective NAVSEA Codes which are assigned the focal point for these disciplines. Cost impact data for Federal regulations and

laws have been extracted to the extent possible from the aforementioned Report prepared by the Commission American Shipbuilding and from other sources.

Progress on Tasks

This is a continuing process and the applicable costs are included in each estimate.

Estimated Time Spent Past Two Years

Approximately 90 percent of one man's time is devoted to this task.

Impact on Other Functions

While NAVSEA 01G has the inherent responsibility to ensure all programs are fully costed, the dollar impact of many of the specialized program costs defy accurate estimates. Considerable time is usually spent in attempting to scope or define the requirements, or when feasible to extract from shipyard bid breakdowns. The function is presently done on a part time basis. The amount of time spent on justification of the gross cost factors can exceed the amount of time spent in estimating it during a budget review process.

Benefits to Navy Budget or Manpower

While the special engineering and management systems reflected in the Ship Systems Engineering and other disciplines, as well as the newer management systems and other specialized programs have the objective of producing a better

end product and at times a lower LCC, the real cost is frequently unkown.

Discussion

The proliferation of Navy Specialized Programs and requirements in its acquisition process increases shipbuilding costs. The shipbuilders over several years have emphasized certain of these requirements as non-beneficial cost drivers, with special reference to reporting requirements, quality assurance programs, role of Defense Contract Audit Agency and monitoring of contractor purchasing actions and systems. The shipbuilders recommend these requirements should be substantially and reasonably reduced. Obviously, their costs are included in the overall acquisition price of Naval ships. Many of the other Specialized Programs have long range benefits to the Navy and are also included in the price.

The inability of both the contractors and the Government to properly price these programs, many of which are only of recent origin, is evident. The estimated cost of conducting the Specialized Programs by the bidder, is frequently spread through each unit cost, for example quality assurance which affects in varying degrees the cost of performing each work unit. The bidder may arbitrarily place the costs in overhead, in other management factors, or it may be separately priced. This lack of a firm data base makes it difficult for NAVSEA estimators to evaluate the cost of each Special Program.

The cost added to the overall acquisition price is considered significant and must be included in all NAVSEA estimates. The introduction of Special Program requirements is not always prefaced by a cost analysis which is needed to provide an understanding of the impact of these requirements on the shipbuilding program.

Findings

- Before a new requirement initiated by DON or DOD is implemented, a cost analysis should be required by the office developing the requirement. The cost analysis should address the cost impact in terms of the contract and of impact on Navy appropriations.

- The shipbuilding industry should be formally solicited for comments on feasibility and cost before the formal issuance of NAVSEA requirements.

- When Congressional legislative programs have a cost impact on the industry, NAVSEA and the Shipbuilder's Council should address the costs during appropriation hearings as a matter of routine.

- Due to the difficulty of knowing the cost impact and the many sources of requirements, consideration should be given to having a focal point or an established board within the Naval Material Command whose function would include responsiblity for monitoring the development of all non-hardware requirements placed on the industry. This would include the requirements that cost impact analyses are made and that industry is solicited for feasibility.

20. COST ESTIMATE VALIDATION

Definition

Cost estimate validation is the critical review process that validates all cost estimates and related cost analysis efforts within headquarters prior to release by the SYSCOM as an official cost estimate.

Purpose

Validation ensures compliance with established estimating procedures and policies, and by examination of the cost details identify errors, inconsistencies, incompleteness and uncertainties which would make estimates unrealistic.

Principal Directives

NAVMATINST 7000.19A of 30 June 1976 requires that every official major weapon system cost estimate transmitted outside of NAVMATCOM shall be documented by the originator of the estimate and reviewed by the applicable SYSCOM Cost Analysis/Estimating Group (CAEG) prior to authentication by the Chief of Naval Material or his designated representative.

The same detailed attention as other major estimates shall be given to GFE/GFI estimates for major subsystems and are to be reviewed by CAEG before being included in an official cost estimate.

Action Code in NAVSEA

Cost Estimating and Analysis Division SEA 01G.

SEA 01G Responsibilities

NAVSHIPSINST 5432.1B CH-14 of 23 March 1971 states that SHIPS 0161 (now SEA 01G) had the responsibility of "clearing" all ship construction or conversion cost estimates going to activities outside of the Command. In addition, it was also responsible for "validating" cost estimates for software requirements on GFM. Under the latest issue of NAVSEA 5400.1, SEA 01G still has the Cost Estimate Validation responsibility.

As the Command focal point for all Cost Estimates, SEA 01G is responsible for ensuring that all such estimates are professional and consistent. It is responsible for preparing justifications for each estimate given to CNM, CNO, NAVCOMPT and Congress. The Program Manager may change estimates prepared for his use, but SEA 01G has direct access to NAVSEA 01 in case of disagreements over estimates.

SEA 01G is also responsible for collecting, validating and/or developing cost estimates for combat system software requirements for GFM for shipboard application.

Identification of Tasks Assigned to SEA 01G

The Division of Cost Estimating and Analysis does validate all ship estimates. Due to insufficient staffing and information, it does not however, fully validate GFM or equipment, but does give it a perfunctory review.

Progress on Tasks

Within the limitations indicated above, SEA 01G does perform its responsibilities.

Estimated Time Spent Last Two Years

Approximately one man-year of staff is devoted annually on these projects.

Impact on Other Functions

Within the limitations of its present validating functions, the present workload is unaffected. Implementation of the GFM validation would affect the manpower application to other functions unless the present staff is increased.

Benefits to Navy Budget or Manpower

Validation of GFM, as well as ship estimates, would improve credibility of the estimates.

Discussion

Cost Estimate Validation, or the critical review process of all cost estimates at a Command focal point, improves the quality of the estimate and assures compliance with uniform procedures and policies. SEA 01G, the NAVSEA focal point for this responsibility, is now performing this function for all ship estimates. It is, however, only performing in a perfunctory manner on GFM. SEA 01G indicates that it is unable to develop a suitable data bank and monitor the GFM responsibility under its present workload without supplementary staff.

Findings

Proper Cost Estimate Validation of both ship and GFM estimates should be performed by SEA 01G, the Command's focal point for cost estimating and cost analysis. The necessary staff member should be provided to develop and maintain a GFM data bank and to perform the necessary validations.

21. CENTRAL COST MONITOR

Definition

The Central Cost Monitor is the organizational unit which acts as the System Command focal point for establishment of estimating policies and procedures to be followed by organizations and indiviudals not within the established central cost estimating group. The monitor establishes measures of accuracy and recommends new techniques or disciplines as needed.

Purpose

This establishes uniform procedures and policies required to produce credible estimates. It includes consideration of, but is not limited to, methodologies, inflation and escalation rates, adequacy of data base, detail and depth of estimate on related cost analysis, and documentation and classification of estimates.

Principal Directives

In a decision paper of 25 June 1971, NAVSHIPS 01 established SHIPS 016 (now SEA 01G) as the central monitor of cost effort operations in NAVSHIPS (now NAVSEA). NAVMATINST. 7000.19A establishes the policy that within each Systems Command, these shall be one focal point referred to as the Cost Analysis Estimating Group (CAEG) which is responsible for cost estimating policy and guidance. This office shall be so identified and positioned

organizationally as to make its preeminence in the cost estimating area readily apparent. The Central Cost Monitor responsibility of SEA 01G is directed in NAVSEAINST. 5400.1 which states:

> "Ensuring that all estimates emanating from the Command are professional and consistent including providing staff assistance and advice on cost estimating to all headquarters and field organizations."

Action Code in NAVSEA

The responsibility is assigned to the Director of Cost Estimating and Analysis (SEA 01G) as the central monitor of all cost operations in headquarters and field organizations.

SEA 01G Responsibilities

The Director is responsible to undertake overviews of headquarters and field cost estimating organizations for systemic or operational weaknesses. He should also critically observe, review and maintain awareness of cost estimating, price analysis and technical cost analyses operations in NAVSEA components. However, he does not have attendant authority for direction, control, or supervision, but rather has the responsibility for advising the authoritative headquarters manager of action needed.

The cost related function Field Audit is part of the Central Cost Monitor function responsibility.

Identification Of Tasks Assigned To SEA 01G

Negligible effort has been undertaken by SEA 01G due to the press of higher priority cost estimating and analysis work. The lack of sufficient staff and the effort being generated over the past few years to produce credible estimates in light of acquisition overruns, has precluded efforts in the Central Cost Monitor function.

Progress On Tasks

There are no evaluations underway at this time.

Estimated Time Spent Past Two Years

Negligible.

Impact On Other Functions

During apportionment or budget reviews, questions invariably arise over estimates in the OPN, WPN and RDT&E appropriations. SEA 01G has on occasion had to devote time and effort to studies and reviews for items in these appropriations, frequently at a time when the office is occupied in responding to SCN "what if " questions. Accordingly, proper time and attention is not always available to assure full consideration to all problems.

Benefits To Navy Budget On Manpower

An opportunity to monitor headquarters and field cost effort operations may result in the development of more credible estimates.

Discussion

Credible cost estimating is a vital factor in the development of military acquisition programs. This is especially true during the present period. Hence, central cost monitoring is a tool that measures estimating accuracy and recommends new techniques or disciplines as needed.

Findings

SEA 01G is the logical organizational unit within NAVSEA to act as the focal point to establish policies and procedures. It is suggested that annually a small group be established under the guidance of SEA 01G to review the various estimating techniques used in NAVSEA to assure credible cost estimates and proper coordination and responsibilities within the Command.

22. DOCUMENTATION

Definition

This relates to maintaining complete records covering the entire history of ship and GFM acquisition estimates, their development, assumptions and data sources, and modifications and reasons therefore.

Purpose

An estimate of a major weapon system and other components is prepared in good faith based on the best available data. Later, usually when higher costs or overruns become evident, the quality of the estimates may be challenged. Thus, the estimator must document each step of the process.

Principal Directives

Documentaion is required by DOD and as most recently required in NAVMAT INST 7000.19A of 30 July 1976. The standard Cost Estimate Documentation Summary Form (NAVMAT 7000/2 -July 1976) sets forth the information to be furnished. This is for use outside of NAVSEA and covers only highlights, namely:

- Technical characteristics
- Cost and procurement assumptions
- Developmental and risk considerations

Documentation of major GFM cost estimates is also required for which NAVSEA 7300/5 Form has been developed.

Action Code

Under the NAVMAT INST, each estimating group is responsible for proper documentaion whether it originates in NAVELEX or NAVAIR, or whether it originates within the several estimating groups of NAVSEA.

SEA 01G Responsibilities

As the NAVSEA focal point for ship acquisition estimates, SEA 01G is responsible for undertaking its own documentation of all estimates. In addition, estimates supplied from other Commands or from within NAVSEA for SEA 01G use should be accompanied with documentation which can be validated before becoming part of the total ship acquisition estimate.

Identification Of Tasks Assigned SEA 01G

SEA 01G undertakes many estimates during each fiscal year. The quality of the estimate is largely dependent upon technical definition, an adequate data base and sufficient time in which to prepare the estimate. Documentation is time-consuming or seems unimportant in relation to the type of estimate required. The same problem affects other Commands and other estimating groups within NAVSEA who may be pressed for time.

Progress On Tasks

Documentation is required for every estimate. SEA 01G staff indicate they maintain more voluminous documentation information than required under NAVMAT Form 7000/2. Review of the Division's records, as well as sources of weapon systems and GFM estimates, indicate incomplete documentation and in many instances the only information is through staff discussions.

Estimated Time Spent Last Two Years

SEA 01G has three staff members who review GFM pricing information for inflation rates, learning curves and inclusion of proper support costs. This is on a part time basis. Collectively, about 1.25 man-years of effort is annually devoted to this subject.

Impact On Other Functions

To the extent documentation requires some work effort, it may affect the overall basic estimating requirements. However, this cannot be quantified. In any event documentation is part of the required estimating process.

Benefit To Navy Budget Or Manpower

Good documentation is one method of identifying the effect each Navy staff member's decision has in the estimating process. This would tend to minimize adjustments to a professional prepared budget.

Discussion

The requirements for proper documentation of official estimates are clear. Review of the estimators' files indicate a paucity of records which would normally clarify many facets of the estimate. Documentation must indicate all phases of an estimate, from early planning to conclusion. These records should be maintained until after the contracts are completed and the final cost adjudicated. Good documentation is the estimator's tool in reconstructing events at a later date.

Findings

Documentation for all estimates and components must be prepared and strengthened for all estimates. All modifications whether made by NAVSEA or others and the reasons therefore should be recorded. The documentation information should be readily available and maintained until the contract is terminated and settled.

23. CONTRACT COST DATA REPORTING (CCDR)

Definition

Contract Cost Data Reporting replaces the series of performance reports that have been known in the past as Cost Information Reports (CIR), Cost/Schedule Control Systems Criteria (C/SCSC), etc., that were required to be periodically submitted by contractors.

Purpose

These reports are used for surveillance and visibility of contractors progress and to ensure that contract results on cost and performance are being obtained. In addition, OSD systems analysis plans to set up and publish cost estimating relationships on ships once sufficient data is available to achieve this goal.

These procedures will provide a basis to assist:

- DODmanagers in assessing the credibility of SYSCOM estimates on follow-on programs
- Project Managers to evaluate their programs from a cost and schedule standpoint

While not evident in the various directives and corrspondence, the CCDR's may also be used in the evaluation of shipbuilders' claims.

Principal Directives

In the 1960's, the Department of Defense initiated a Cost Information Report (CIR) and Cost and Economic Information Reporting (CEIR) system as a means of tracking the costs of various weapons systems. Initially, it was limited to aircraft, missile, and space systems.

SECDEF Directive 7041.7 of 7 July 1964 directed that military departments establish a Cost and Economic Information System (CEIS). On 9 October 1964 SECNAV Instruction 7040.4 established the CEIS within DON and assigned responsibilities. Following this, SECNAV on 4 October 1965 submitted a Program Change Proposal to SECDEF requesting an extensive increase in personnel ceilings over FYs 1966 - 1970 for CEIR implementation. In a memorandum from the Assistant SECDEF of 28 February 1967 to the Army, Navy and Air Force, CIR procedures were extended to include families of ships, as well as other systems, and recommendations were invited from the military departments. Subsequently, in a memorandum of March 22, 1967 the Comptroller of the Navy requested NAVMAT in conjunction with NAVSHIP to undertake a comprehensive study of CIR concepts to shipbuilding. In its memorandum of December 19, 1967 NAVMAT advised the Comptroller --

> "...implementing CIR in shipbuilding would not appear to be a cost effective approach when the high cost and effect of obtaining CIR data is weighed against any improvements that might be

realized in the current system of shipbuilding cost analysis. If, however, it is decided that CIR must be applied to shipbuilding programs, it is recommended that the rate of implementation be commensurate with resources available."

Considerable correspondence followed on the difficulty of modifying contractors' cost systems to develop cost information of value to the Navy. A Cost/Schedule Control System Criteria Joint Implementation Guide, (NAVMAT P 5240) dated 31 March 1972 was issued to provide uniform guidance for implementation of DOD Instruction 7000.2.

In 1972, the validation of the contractors cost accounting system became an issue, which prompted NAVSEA to establish a group (now SEA 077) to review the accounting of labor, material and overhead and to develop a tracking system for everything entering and leaving the shipyard. At present, only Lockheed and Bath have been validated, with Electric Boat close to being acceptable. In the meanwhile, CCDRs are being received from all contractors, whether validated or not.

In a memorandum of 17 June 1974 to NAVSHIPS, Admiral H. G. Rickover requested that nuclear shipbuilding be exempt from the requirements of CCDR since the raw data presented in these reports is frequently taken out of context by unqualified persons. Unlimited distribution of such raw data would result in NAVSHIPS personnel spending an increasingly greater amount of time interpreting this data and answering questions.

In spite of such letters, NAVSEA has been directed to implement CCDR and is doing so in all future program awards. The Shipbuilders Council has established a committee to review and make recommendations in this area. To date, the shipbuilders see no need for this report.

Action Code In NAVSEA

The Program Managers are responsible for monitoring the various cost and schedule reports submitted by the contractors. SEA 077 is responsible to insure that the contractor has a validated accounting system or is trying to achieve it.

SEA 01G Responsibilities

Since NAVSEA is slowly implementing a program that neither they nor the shipbuilders desire, there have been many complaints about the system of reporting and what is reported. No one overall code in the Command appears to coordinate the action of each SHAPM and varying requirements exist with respect to the specific forms that must be filled out. In the absence of one overall coordinator, SEA 01G has been directed to resolve these conflicts on a case by case basis. In this regard, SEA 01G considers these reports to be of little value since they are received too late to allow any specific action to be taken for an on-going program and also the final returned costs are not received until five to seven years

have elapsed. At that time, the type of ship built may not be programmed anymore.

Identification Of Tasks Assigned To SEA 01G

As indicated above, SEA 01G is called on to resolve the issues that invariably occur when a contractor complains about the CCDR system or its specific implemenation by the various SHAPMs.

Progress On Tasks

Since no one is in charge of overall implementation, the total problem is not yet resolved.

Estimated Time Spent Last Two Years

Insignificant effort is directed toward using CCDR information at the present time. SEA 01G estimates that these reviews would require one-half man-year of effort annually. Additional staff is not required if SEA 01G is just to continue its present role.

Impact On Other Functions

This takes time and effort, usually of the top supervisors in SEA 01G.

Benefits To Navy Budget Or Manpower

Periodic information on contract costs and schedules should assist in evaluating programs, however, this is not always being accomplished in a timely manner.

Discussion

The CCDRs and other similar cost and schedule reporting systems are costly to provide, difficult to obtain with meaningful information, and are of limited value to NAVSEA in developing estimates. The shipbuilding contractors vigorously oppose the details involved which often require a change in their cost accounting systems.

Findings

The value of requiring CCDRs should be reevaluated and simplified. A Command focal point should be officially established. In addition, it should be determined what contract cost and scheduling information may be most useful to NAVSEA and other Commands.

VIII. THE GFM COST ESTIMATING CAPABILITY OF SEA 06 AND SEA 04 IS FRAGMENTED

In order to evaluate the cost estimating capability of the Naval Sea Systems Command for Government Furnished Material (GFM), the following eight major systems were reviewed in the depth that existing records and certain offices would permit.

Major Systems		
5" 54 Cal. MK 45 LWG	-	SEA 65311
MK 86 Gun Fire Control System	-	SEA 65322
AN/SPS-40 Radar	-	SEA 6524
AN/SPS-55 Radar	-	SEA 6524
AN/UYK-7 Computer	-	SEA 044/045
AN/SQS-53 Sonar	-	SEA 661C
PHALANX (CIWS)	-	PMS 404
LM 2500	-	PMS 399

1. THE CASE STUDIES SHOW AN ABSENCE OF COST CONTROL AND VERY LIMITED IN-HOUSE COST ESTIMATING OR COST ANALYSIS CAPABILITY

In attempting to follow the historical track and comparison of Government Furnished Material cost estimates for the eight GFM, the variety of formats and the absence of supporting documentation suggest a very weak

management for and lack of coordination of the cost estimating process by the Acquisition/Project Managers of SEA 06. In part this lack of management and definition in the cost estimating process may reflect the numerous reorganizations experienced by the various NAVSEC, NAVORD, and NAVSEA codes that now make up the Naval Sea Systems Command, though this should not account for its continued existance. With the exception of the SEA 06H code for sonar, neither cost estimates nor cost analyses are the prime concern of the SEA 06 Acquisition/Project Managers. The following is a summary of the review of the above eight GFM.

- The SEA 06/04 codes are not staffed with dedicated cost estimate groups. There are only two professional cost estimators in SEA 06 and none in SEA 04.

- Cost data banks were not to be found in NAVSEA. Cost data can be found throughout the various codes in file cabinets and is included as part of the system/equipment technical files. Complete files as to initial cost estimates for an initial technical baseline and the changes to and rationale for are not to be found. Exceptions are SEA 06H where data banks are in the custody of a private contractor and SEA 01G where cost data is received in various formats but not to the detail required for tracking cost estimates or cost analysis.

- It is too soon to evaluate the effects of DOD Inst. 7000.2 regarding return cost information. Thus far the only return cost information to be found was in SEA 02 contracts. An analysis of a technical modification vs. estimated costs as compared with the same technical modification with the actual costs cannot be made.

- The source of escalation and inflation predictions varies as in most cases these factors are applied by SEA 01G. There are some SEA 06 codes which prefer to use inflation factors provided by the manufacturer while other codes will use DOD indices.

- In most cases cost estimating is done by the SEA 06/04 codes updating the latest SEA 02 contracts by inflation factors and/or by contacting the manufacturer. The exception is SEA 06H as they contract for sonar cost estimates which for a new system starts out parametric and becomes engineering as the system develops.

- Cost estimates provided by SEA 06H and SEA 04 in most cases were within ten percent of the actual costs. However, most of the cost estimate provided by other SEA 06 codes did not follow any consistent pattern.

- PMS 404 did employ a private contractor to validate the cost estimate for the PHALANX (CIWS) and PMS 403 for the AEGIS System. Validation of cost estimates for other SEA 06 or SEA 04 GFM has not been done.

- Cost estimating is usually done by SEA 06/04 updating contracts. This is a natural fall out of the many repeat buys for systems/equipment in production. For the cost of equipment modifications, the manufacturer is usually contacted.

- Cost estimating by the contractor can be by analogy, parametric or engineering methods. For SEA 06H a private contractor will at various times for different systems/equipments use all and/or part of all three.

- The SEA 06 and SEA 04 cost estimates are generated for new development, budget, Ship Project Directives, or contract bid purposes.

2. NAVSEA DOES NOT HAVE THE CAPABILITY FOR IN-HOUSE COST ESTIMATING

Lack of training and personnel therefore compel the SEA 06 Acquisition/Project Managers to lean heavily on past contract data and/or by contacting the manufacturer for current information to be used for all of their estimates. This system has proven to be effective in so far as equipment that is in produc-

tion is concerned. However, when new equipment is to be estimated, other than Sonar at the present time, SEA 06 does not have the in-house capability to estimate a budget cost or to determine whether or not the bids submitted by competing manufacturers are justified.

In the Design-to-Cost (DTC), Design-to-Price (DTP) type of equipment development it is important that the equipment cost parameters satisfy the cost requirements. To establish DTC/DTP goals or to determine whether contract bid costs are excessive, SEA 06 must go outside the Command to have a private contractor develop parametric costs estimates. In effect a private contractor is checking a private contractor (i.e., manufacturer). In other cases within NAVSEA, PMS 403 (AEGIS), PMS 404 (PHALANX (CIWS)), for example, a private contractor has developed and maintains current, parametric cost models to aid the NAVSEA office to monitor the manufacturer's costs.

(1) Many Different Offices In NAVSEA Are Involved In The Cost Estimating Functions

Throughout SEA 06 there are presently 24 different offices, listed on following pages, that are procuring Government Furnished Material (GFM). They establish, and initiate all subsequent changes to, the system/equipment technical baseline(s). These offices are responsible for SEA 06 GFM Life Cycle Cost (LCC) and for the cost estimates that are initially developed (and changed in accordance with system/equipment modifications) and forwarded to SEA 01G as

NAVSEA 06 CODES PROCURING GFM

SEA 652 Surveillance Systems Sub Group

6522 - Advanced Systems Division
6523-3-D Radar Division
6524-2-D Surface and Navigation Radar

SEA 653 Surface Gun Systems Sub Group

SEA 653 G - MK 92 FCS/MK 75 Gun Mt. Project Office
SEA 6521 - Gun Division
SEA 6532 - Gun Fire Control Division

SEA 654 Surface Missiles Systems Sub Group

SEA 6541 - Long Range Missile Systems Division
SEA 6542 - Medium Range Missile Systems Division
SEA 6543 - Surface Launched Missile and Launcer Division

SEA 06H Undersea Warfare Systems Sub Group

SEA 06H2 - Advance Systems and Integration Office
SEA 06H3 - Plans, Program, Material and Financial Management Office

SEA 660 Submarine Systems Sub Group

SEA 660C - Sonar Division
SEA 660D - Weapons Systems and Control Division
SEA 660F - AN/BQQ-5 Sonar Division
SEA 660G - Trident Sonar and DWS Division

SEA 661 Surface Systems Sub Group

SEA 661C - Sonar Division
SEA 661D - Weapons Systems and Control Division
SEA 661E - Acoustic Warfare and Communications Division

SEA 662 Torpedo Sub Group

SEA 662C - Heavy Torpedo and Targets Divisions
SEA 662D - Torpedo Systems and Fleet Support Division
SEA 662E - Lightweight Torpedo Division

SEA 663 Mine and Special Warfare Sub Group

SEA 663C - Mine Special Warfare Division
SEA 663D - MCM, Riverine, and IVW Division
SEA 663E - PRAM Acquisition Office

an input for SCN budget estimates and to the Ship Logistic Managers for WPN appropriations. In addition, these offices keep current the technical and cost data for the Ship Projective Directives (SPD) and as required, provide cost data to SEA 02 to aid in their selection of a successful bidder. The many offices are therefore concerned in some way in the cost estimating process and this fragmentation of the cost responsibility, whether it be for budget purposes or in the procurement-contract-production cost cycle, has resulted in a hodge-podge of non uniform cost data recorded on memoranda, cost breakdown work sheets, letters, notes, etc. The lack of adequate documentation has made the traceability and accountability of cost estimates a difficult and at times an impossible task. Figure D.20 indicates the wide variety of cost estimating practices which exists within the GFM organizations.

(2) Standardization Of Cost Documentation Is Required By SEA 01G

The cost data which has been provided SEA 01G does not usually include the breakdown of costs on a line item basis. When the costs are documented per line item, the categories, for the exact same equipment, are not always the same so an evaluation of the cost estimating process can only be made of the hardware costs and at times some other common support items. NAVMAT Inst. 7000.19A 01/

MCC of 30 July 1976 requires that the Acquisition/Project Managers use the Cost Estimate Documentation Summary (NAVMAT Form 7000.2), Figure D.21 for their cost estimates. This form will do much to standardize cost data, however it does not break the cost categories down to the level required to analyze costs. The cost categories however, are broken down by another Cost Estimate Documentation Summary, NAVSEA 7300/4 (4-75), Figure D.6, Chapter III. In order to provide SEA 01G, the SEASYSCOM Cost Estimating/Analysis Division, with the required cost data in a standard form it is our recommendation that NAVSEA form 7300/4 (4-75) be made part of NAVMAT Inst. 7000.19A for all GFM.

Again with the exception of SEA 06H, organized cost data banks are non-existant within the SEA 06 codes. What equipment files that were reviewed within the SEA 06 organization revealed excellent technical data but poor cost data. This is no doubt due to the lack of emphasis placed on cost estimates as discussed earlier.

CHARACTERISTICS OF GFM CODES STUDIED

	SEA 65311	SEA 04	SEA 65322	PMS 399	PMS 404	SEA 661C	SEA 06H
Dedicated Cost Estimating Staff							
. Yes							X
. No	X	X	X	X	X	X	
. Number of Professional Estimators	0	0	0		0	0	2
Cost Data Banks Are:							
. Good					X		
. Mediocre		X		X		X	
. Poor							
. Computerized							
. In Contractors Custody					X		X
. Not observed	X		X				
Return Cost Data From							
. Contracts	X	X	X	X		X	X
. 7000.2					X		
. None							
. Manufacturer (not 7000.2)							X
Escalation & Inflation Predictions							
. Uses OSD						X	
. Applied by SEA 01G	X		X	X	X		
. Develops own							
. Uses Contractors/Manufacturers		X					X
Review Procedures							
. In-house					X		
. None observed	X	X	X	X		X	
. By Contractor							X
Cost Estimates Are Done							
. By updating SEA 02 contracts	X	X	X				
. By private contractor					X		X
. By contacting the manufacturer	X		X		X	X	
. In-house							X
. By updating SupShip data				X			

	SEA 65311	SEA 04	SEA 65322	PMS 399	PMS 404	SEA 661C	SEA 6524	SEA 06H
Cost Estimates Are Usually								
. Low								
. High	X			X		X	X	
. Vary			X					
. Within 10 Percent		X			X			X
Validation Of Cost Estimate								
. By Private Contractor					X			X
. Not Done	X	X	X	X		X	X	
. In-house								
Type Of Estimating Done By Navy								
. Analogy (update contracts)	X	X	X	X		X	X	
. Parametric					X			
. Engineering								
Type Of Estimating Done By Contractor								
. Analogy								X
. Parametric					X			X
. Engineering					X			X
Estimate Is For What Purpose								
. Development					X			X
. Budget	X	X	X	X	X	X	X	X
. Contract	X	X	X	X	X	X	X	X
. SPD	X	X	X	X	X	X	X	X
. SARS					X			X

FIGURE D.20

FIGURE D.21

COST ESTIMATE DOCUMENTATION SUMMARY 1/

NAVMAT 7000/2 (7-76)

Report Symbol
OPNAV 7000-1

Serial Nr. (e.g., SEA 11-76)	Classification
System Title/Model Nr.	Prepared by (Name, Title) Phone
Purpose (e.g., CPAM, POM, Budget, DSARC, DNSARC, etc) Original ☐ Revised ☐	Activity (Name & Code)
Date of Preparation / Date/Serial of Previous Estimate	

Technical Characteristics/Pertinent References

Cost and Procurement Assumptions (e.g., Production Quantity, Type Contract, Schedule, etc)

Stamp Category of Cost Estimate Here

See Below for Cost Categories

COST CATEGORY

Developmental and Risk Considerations (Indicate range of uncertainty)

COST SECTION (See Reverse)

COST ESTIMATE CLASSIFICATION

The following are standard classifications of cost estimates to be used to the extent applicable. If a different cost classification system is more appropriate, due to unique System Command requirements, the Directive providing any other classification used must be referenced in the documentation.

CLASS A	DETAILED COST ESTIMATE (Post Budget - Contract Estimates) Estimate based on contract plans and evaluation of firm quotations for major material items.
CLASS B	BID EVALUATION COST ESTIMATE (Post Budget - Contract Estimates) Estimates based on contract plans and evaluation of contractor proposals in response to a RFP.
CLASS C	BUDGET QUALITY ESTIMATE Estimate based on an engineering analysis of detailed characteristics of item under consideration.
CLASS D	FEASIBILITY ESTIMATE Estimate based on technical feasibility studies and/or extrapolated from higher quality estimates of similar items.
CLASS E	COMPUTER ESTIMATE Estimate developed usually by a computer model and based on cost estimating relationships and gross parameters.
CLASS F	BALL PARK ESTIMATE Quick cost estimates prepared in absence of minimum design and cost information and based on gross parameters.
CLASS X	DIRECTED OR MODIFIED COST ESTIMATE Estimate not developed by SYSCOMS through normal cost estimating processes.

1/ Use additional sheets if required

FIGURE D.21A

COST SECTION

Base FY	Current FY	Completion FY

DTC Goal

Original ______ Previous ______ Current ______

(Then Year $/M)	Prev. Yrs (PY)	Curr. Yr (CY)	Budget Yr (BY)	BY +1	BY +2	BY +3	BY +4	To Completion 1/	Total
R&D (Qty/$)									
Annual Escl. Rate (R&D)									
Production (Qty/$)									
Annual Escl. Rate (Prod)									
Support Investment ($)									
Annual Escl. Rate (SI)									
O+S Costs ($)									
Annual Escl. Rate (O+S)									
Total (Qty /$)									
Deliveries									

COST

Stamp Category of Cost Estimate Here

See Reverse Side for Cost Categories

CATEGORY

CAEG Review (Name, Title, Date)	Authenticated by (Name, Title, Date)	Classification

1/ Indicate number of years used for total program life 2

IX THE PRIMARY RECIPIENT OF COST ESTIMATES IS THE SHIP ACQUISITION PROJECT MANAGER

In 1974, the Navy instituted the Ship Acquisition Project Manager (SHAPM) concept to direct and coordinate the ship procurement process. The SHAPMs operate from a matrix type organization where they coordinate functional groups servicing all project managers. The estimating function residing in SEA 01G is one of the functional organizations which serves these project managers.

Under this arrangement, the SHAPMs are responsible for presenting budget estimates for their own programs. The total ship program end cost estimate is prepared by SEA 01G and concurred in by SHAPM staff when the budget support papers and forms are prepared. The SHAPM staff do not consider ship cost estimating as a primary responsibility even though they do have, in most cases, personnel with estimating experience gained through either the repeated review process or by virtue of past experience -- in some cases in SEA 01G.

The estimate submitted to the SHAPM by SEA 01G is usually developed with the aid of consultation with the SHAPM on the staff level. After agreement has been reached between SEA 01G and the SHAPM, the Project Manager takes responsibility for the estimate as it goes through subsequent review up through the command.

Five SHAPMs were interviewed regarding the adequacy of the budget estimate prepared by NAVSEA. There are presently fourteen SHAPMs in the NAVSEA command. There was a general consensus on the following points:

- The estimates prepared by SEA 01G are satisfactory.
- The staff of SEA 01G is very thin.
- The estimating process could be improved by providing SEA 01G with
  - more time in which to prepare estimates
  - more qualified staff
  - greater ship definition
- Having a central estimating capability such as SEA 01G is preferred over having separate estimating capability for each PM.
- The present organizational location is satisfactory.
- The grade structure of SEA 01G should provide a career ladder as desirable as in other competing organizations within the Navy.

The SHAPMs, however, had divided opinion as to their responsibility to provide SEA 01G with technical or cost data that are required in order to make a good estimate. Several SHAPMs have assumed a responsibility to provide this data on a voluntary basis, while others said it was available if SEA 01G asked for it, but felt no obligation to furnish it otherwise.

Even though the SHAPMs do not have an organized estimating capability as such, they spend from 40-50 percent of their professional time on financial management. During the course of this work, the SHAPMs come in contact with a wealth of cost information.

One of the most sensitive elements in the cost estimating equation is the building period, i.e., when it is estimated to start and end. The SHAPM, supported by SEA 075, makes this determination and it is used in the SEA 01G estimate. Several factors enter into this determination. First and foremost is the urgency to get new ships into the fleet as soon as possible. This primary consideration is tempered by such considerations as shipyard capability, equipment lead time requirements and many others. These estimates are more inclined to be zero based than predicated upon past program experience.

The SHAPM has little effective control over the cost of his program. He has some control over changes, but he cannot control direction from above regarding use of program funds for unbudgeted and often unrelated expenses. He cannot control what he has to pay for GFM, i.e., weapons, etc. These costs are set by the various GFM program managers. The SHAPMs pointed out also that they have no control over shipyard costs.

X. COST ESTIMATING OUTSIDE NAVSEA

In order to place the NAVSEA headquarters estimating function in perspective with other DOD and industrial entities that are tasked with similar responsibilities the estimating functions in the following organizations were reviewed.

Within the Navy.

Naval Electronics Command	(NAVELEX)
Naval Air Command	(NAVAIR)
Naval Facilities Command	(NAVFAC)
Military Sealift Command	(MSC)
Office of Chief of Naval Operations Systems Analysis Division	(OP96D)
Naval Ship Engineering Center	(NAVSEC)

In DOD outside Navy.

Army Directorate of Cost Analysis	
Army Material Development and Readiness Command	(DARCOM)
DOD Cost Analysis Improvement Group	(CAIG)
Center For Naval Analysis	(CNA)

Shipbuilding Industry.

Newport News Shipbuilding & Dry Dock Co.	(Newport News)
National Steel Shipbuilding Co.	(NASSCO)
Bethlehem Steel Co. Shipbuilding Division (Sparrows Point Baltimore)	(Beth Sp.Pt.)

In order to appreciate the wide range cost estimating/cost analysis responsibilities and approaches see Figure D.22 which is a matrix showing organization vs. their responsibilities and characteristics.

FIGURE D.22

COMPARITIVE ANALYSIS
NAVSEA VS. OTHER ESTIMATING ORGANIZATIONS

	NAVY (Outside NAVSEA Headquarters)						OTHER DOD			PRIVATE SHIPYARDS			NAVSEA		
ESTIMATING FACTORS	NAVELEX	NAVAIR	NAVFAC	MSC	OP96	NAVSEC	Army (DARCOM)	CAIG	CNA	Beth. St. Sp. Pt.	Newport News	NASSCO	SEA 01G	SEA 06	SEA 04
Major Responsibilities															
Development Estimates				1st	1st	1st	2nd	1st	1st				3rd		
Budget Est.	3rd	1st	1st										1st	3rd	3rd
SPD Est.	2nd													1st	1st
Contract Est.	1st	3rd	2nd										2nd	2nd	2nd
Life Cycle Cost		2nd				2nd	1st								
Bids/Proposals										X	X	X			
Secondary Responsibilities															
Development Estimates	X													Same	
Budget Est.							X								
Contract Est.							X								
LCC		X				X							X	X	
Should Cost	X	X					X						X	X	
DTC							X						X	X	
DCP							X						X		
Economic Analysis	X	X			X		X	X	X	X	X	X	X		
Annual Value Product Estimated															
Over 3 Billion		X					X						X		
Between 1 and 3 Billion					X			X	X						
Between 1 and 0.5 Billion	X		X	X		X									
Under 0.5 Billion										X	X	X		X	X

LEGEND:

NA - Unknown Quanity
X - Indicate Applicability

1st - Primary Consideration
2nd - Secondary Consideration
3rd - Tertiary Consideration

FIGURE D.22A

COMPARITIVE ANALYSIS
NAVSEA VS. OTHER ESTIMATING ORGANIZATIONS

	NAVY (Outside NAVSEA Headquarters)						OTHER DOD			PRIVATE SHIPYARDS			NAVSEA		
ESTIMATING FACTORS	NAVELEX	NAVAIR	NAVFAC	MSC	OP96	NAVSEC	Army (DARCOM)	CAIG	CNA	Beth. St. Sp. Pt.	Newport News	NASSCO	SEA 01G	SEA 06	SEA 04
Product Complexity															
Highly Complex	2nd	X					X							1st	2nd
Complex	1st				X	X	X	X	X		1st	2nd	1st	2nd	1st
Commerical Stote of Art			X	X			X			X	2nd	1st	2nd		
Types Of Estimates															
Analogy	1st			Some	2nd			1st					2nd	1st	1st
Parametric	2nd	Most		Some	1st	X	X	2nd	1st				1st		
Engineering			Most	Some						X	X	X			
Computer Usage															
Little				X	X								X	X	X
Moderate	X		X							X	X	X			
Extensive		X				X	X	X	X						
Primary Data Source															
Bid Data					1st	X		X	X				X		
Return Cost		1st								1st	1st	1st			
Past P.O. (Contracts)	1st									3rd	3rd	3rd		3rd	1st
Manufacturer	2nd	2nd		1st			1st			2nd	2nd	2nd		1st	2nd
Consulting Contractor	3rd		1st		2nd									2nd	
Published Dato			2nd	2nd											

LEGEND:

NA - Unknown Quanity
X - Indicate Applicability

1st - Primary Consideration
2nd - Secondary Consideration
3rd - Tertiary Consideration

FIGURE D.22B

COMPARITIVE ANALYSIS
NAVSEA VS. OTHER ESTIMATING ORGANIZATIONS

ESTIMATING FACTORS	NAVY (Outside NAVSEA Headquarters)						OTHER DOD			PRIVATE SHIPYARDS			NAVSEA		
	NAVELEX	NAVAIR	NAVFAC	MSC	OP96	NAVSEC	Army (DARCOM)	CAIG	CNA	Beth. St. Sp. Pt.	Newport News	NASSCO	SEA 01G	SEA 06	SEA 04
Data Bank															
Scale of Completeness and Accessibility (1 = Highest) 1										X	X	X			
2	X	X	X				X								
3													X		X
4					X	X		X	X					X	
5				X											
Percent Procurement Repeat Purchase															
Over 75%	X	X				X	X				X			X	X
Between 25 - 75%										X		X			
Under 25%			X	X	X			X	X				X		
Primary Estimate Source (New Prod.)															
Governement Staff	2nd	1st	2nd	X	X	X		X	X				X	2nd	
Contractor (Cons.)			1st											1st	
Manufacturer	1st	2nd					X								
Shipyard Staff										X	X	X			
Time Allowed For Best Estimate										6-17 wk.	12-15 wk.		1 wk.		
Staff															
Cost Estimators (CE)	6	50-60	55		Ships 2		±100	Ships 1	Ships 1	20	37	19	14	2	1
Cost Analyst (CA)						5	260						15		
CE/CA Secondary Function	50+	NA	Very Few	5			NA						None	31	36

LEGEND:

NA - Unknown Quanity
X - Indicate Applicability

1st - Primary Consideration
2nd - Secondary Consideration
3rd - Tertiary Consideration

FIGURE D.22C

COMPARITIVE ANALYSIS

NAVSEA VS. OTHER ESTIMATING ORGANIZATIONS

ESTIMATING FACTORS	NAVY (Outside NAVSEA Headquarters)						OTHER DOD			PRIVATE SHIPYARDS			NAVSEA		
	NAVELEX	NAVAIR	NAVFAC	MSC	OP96	NAVSEC	Army (DARCOM)	CAIG	CNA	Beth. St. Sp. Pt.	Newport News	NASSCO	SEA 01G	SEA 06	SEA 04
Estimotor Staff Experience															
Government	Some	5-10 yr.	Extensive	NA	Not Exten-sive	3-11 yr.	6-10 yr.	Little	Exten-sive				6	5-10 yr.	5-10 yr.
Industry Allied	1-2 yrs.	Little	Extensive	NA						20-35 yr.	28 yr.	5-10 yr.			
Industry (Not Allied)	Some	Little		NA											
Staff Education Level															
Advanced Degree					X			X	X						
College	X	X		X		X	X						X	X	
High School			X							X	X	X			X
Staff Training															
Extensive															
Moderate													2nd		
Some														2nd	
Shipyard or Manufacturer On Job	X	X	X	X	X	X	X	X	X	X	X	X	1st	1st	X
Staff Poy															
(Journeyman Estimator)															
GS 15 or above					X				X						
GS 14								X							
GS 13		X		X		X	X							X	X
Less Than ($25,000)	X		X							X	X	X	X		

LEGEND:

NA - Unknown Quanity

X -- Indicate Applicability

1st - Primary Consideration

2nd - Secondary Consideration

3rd - Tertiary Consideration

1. <u>A DIRECT COMPARISON OF THE CA/CE (COST ANALYSIS AND COST ESTIMATING) FUNCTION IN NAVSEA WITH THE OTHER ORGANIZATIONS IS HARDLY POSSIBLE BECAUSE OF THE DISSIMILARITIES OF PRODUCT, RESPONSIBILITIES AND CIRCUMSTANCES</u>

(1) <u>NAVSEA Vs. Army And NAVAIR</u>

NAVSEA 01G has a very broad range of responsibilities to develop estimates from the conceptual stage up to contract award. In the overall picture, these responsibilities with respect to investment cost estimating are similiar in scope and program size to NAVAIR and the Development And Readiness Command (DARCOM) of the Army.

In carrying out these responsibilities, it is found that the Army is dedicating considerably more resources to CA/CE than either NAVSEA or NAVAIR with approximately 360 people involved, while NAVAIR and NAVSEA have 60 and 32 respectively.

The Army has instituted a cost analysis program base using LCC techniques which is carried uniformly through all levels of the service. Since the initial LCC investment is a small part of total procurement cost, a large number of the 360 staff are dedicated to other elements in the LCC analysis. NAVSEA and NAVAIR, with the fewer CA/CE people, are primarily concerned with initial investment cost.

The Army and NAVAIR make extensive use of manufacturer return cost data and computerized assistance for data storage and referral as well as for parametric estimating.

The type of CA/CE staff of these three organizations are generally comparable in education and experience. The average staff member is young, has a college education and most of his experience has been with the Government. In general it was found that people with engineering background were in the minority in NAVAIR and Army but slightly in the majority in NAVSEA. The pay level of these organizations is about the same.

With respect to estimating methodology, some differences are found.

- Army - Extensive use of computer models for Baseline Cost Estimate (BCE) and Independent Parametric Cost Estimate (IPCE) to check engineering estimates for Life Cycle Costs (LCC).
- Extensive use of manufacturers and contractor detailed engineering estimates which are validated by Army estimators for budget estimates (Example, XM1 Tank).
- Army cost estimators maintain very close contact with counterparts in industry.
- NAVAIR - Extensive use of computer aided estimating with return cost data bank.
- NAVSEA - Manual parametric estimating
- Informal and dispersed data bank based primarily on nine cost group bid data.

If any general conclusion can be drawn from this comparison it is that the Army and NAVAIR have made greater use of return costs and computer assitance in data processing and parametric estimating.

(2) NAVSEA Vs. NAVELEX

NAVELEX has a relatively small annual budget compared to NAVSEA and correspondingly fewer and less experienced estimators. NAVELEX estimating staff spends a large part of its time in the manufacturers plant validating proposals, somewhat like the Army. In contrast, NAVSEA estimators are relatively isolated from personal contact with industry.

NAVELEX is conducting Design To Price (DTP) procurement for ECM System which is stated to be proving quite successful. This could be contrasted to the less successful FFG Design To Cost (DTC) effort.

This SYSCOM has a computerized data bank containing a complete record of past and current acquisition costs. The budget estimating process is usually relatively simple compared to NAVSEA since 90 percent of dollar value budgeting is for equipment that is now on order for previous programs.

In comparing NAVELEX to NAVSEA, several points stand out; the computerized data bank and wide personal contact with industry, which NAVSEA lacks.

(3) NAVSEA Vs. NAVFAC

A comparison of NAVSEA with NAVFAC is difficult because of the great difference in sophistication of their products. However, with respect to estimating procedure and approach, some meaningful observations can be made.

The first is with respect to product definition where NAVFAC develops its budget estimates only after 30 percent of the detailed design has been completed. These are engineering estimates in considerable detail as compared to the nine cost group estimates customarily prepared by NAVSEA. Second, the estimating staff is of grade GS 11 - 12 level, generally with high school education but usually with extensive experience in the commercial construction business.

NAVFAC headquarters develops estimating guidance but does not do any estimating, of which 75 percent is done by architectual and engineering firms and 25 percent done by the NAVFAC field offices. In contrast, NAVSEA headquarters does both of these functions.

(4) NAVSEA (Headquarters) Vs. NAVSEC

NAVSEC had developed a good start in an estimating technique using a computer calculated parametric ship estimating model. Further development of this program to accommodate updated return cost and bid data in greater detail would provide a excellent basis for a rapid response estimating capability. NAVSEA 01G does not use this capability at present.

(5) NAVSEA Vs. OP96 & CAIG

OP96 and CAIG have a very limited capability to do ship cost estimating due to the small staff, product identification and data banks. There is very little in capability or technique thats these two validating organization have that would be of any appreciable help to NAVSEA.

(6) NAVSEA Vs. Military Sea Command (MSC)

MSC does estimating on an ad hoc basis on several projects each year. Its capability is generally limited to making estimates based on informal industry contacts that may be useful for commerical type construction. Their estimates are usually based on self generated conceptual designs which often provide a more solid foundation than many estimates made in NAVSEA.

(7) NAVSEA Vs. Shipyards

The shipyards have an entirely different estimating problem than NAVSEA. The shipyards must make accurate estimates as to how much it will cost them to build a ship. This price is normally valid for 90 days and usually 20,000 to 30,000 man-hours is devoted in developing a good estimate for a naval ship. It must be accurate within 5 percent in order not to destroy the profit margin. In contrast, NAVSEA is expected in the eyes of Congress to do at least as well, two to two and one-half years before award, with 40 to 80 man-hours of effort, often with only a conceptual design for guidance.

The lesson that can be drawn from reviewing shipyard estimating techniques, that are not affected by the contrasting requirements is that the shipbuilding industry believes accurate estimates must be based on:

- Return cost data
- Good product definition
- Engineering detail
- Vendor quotes
- Limited price exposure (making offer good for limited time)
- Use estimators having shipyard experience

NAVSEA does not follow this procedure, partly because the system under which it operates does not permit it and partly because shipyard estimating techniques are not necessarily recognized as being essentials to quality budget estimating.

NAVSEA could benefit from shipyard experience by:

- Using return cost data
- Estimating in more detail
- Use vendor quotes (if time permits)
- Improve product definition
- Using more estimators with shipyard experience

The comparision of the estimating responsibilities between NAVSEA and the shipyards is one that is convenient to make but easy to misunderstand.

The estimating assignment given the Navy estimctors is much more complex than given a shipyard estimator. The small estimating staff in Navy is now formulating yearly budgets of six to eight billion dollars for five advance years at a time; whereas any single shipyard's estimating staff rarely does over 500 million dollars in estimates for one year, with a larger staff.

The shipyard estimating staff are usually limited in the types of ships they are required to consider because of shipyard building limitations. On the other hand the Navy must estimate all types of complex ships and weapons. The Navy estimators are engaged in all types of estimates from conceptual to contract and numerous other cost related activities. The shipyard estimators on the other hand spend 90 percent of their time on bid or proposal estimates.

Probably the greatest contrast between the shipbuilder and the Navy is the degree of engineering data available upon which to base an estimate. The shipyard has contract plans and specs and 90 days to do the estimate. The Navy has, for a budget estimate, at best a preliminary design and usually only a few weeks estimating time.

(8) NAVSEA Vs. Center For Naval Analysis (CNA)

The CNA ship cost analysis function is now a one and one-half man operation which does three of four studies each year for CNO. The significant feature of the CNA operation is the use of a parametric computer model using a 60 element breakdown compared to the NAVSEA and NAVSEC practice of using nine cost groups.

(9) NAVSEA 01G Vs. NAVSEA 06

SEA 06 Weapon Systems and Engineering Directorate has little, if any, significant estimating capability as evidenced by the fact that only two staff members are regarded as full time estimators, with 39 others involved in cost matters from time to time. Cost information is primarily obtained directly from manufacturers or consultants and involves little original estimating. Its data bank and cost records are very fragmented, except in the case of sonar.

NAVSEA 01G relies heavily SEA 06 for budget estimates which are considered by IMA to involve a high degree of uncertainty.

(10) NAVSEA 01G Vs. NAVSEA 04

NAVSEA 04 Fleet Support Directorate provides estimates to SEA 01G on GFM identified as Hull, Mechanical, and Electrical (HME). These components include such items as UYK-7, compressors, gyro compasses, pumps, navigational equipment, etc. These are usually repeat purchases so estimating future costs are simplified. Prices are usually obtained from the manufacturers. NAVSEA 01G also relies heavily on budget estimates from SEA 04 which are also, as in the case of estimates from SEA 06, considered to involve substantial risk.

(11) The Comparative Analysis Of Estimating Practices Outside Of NAVSEA With SEA 01G

The review of the estimating functions outside of NAVSEA provides a basis for these conclusions.

- Within the Navy, NAVSEA 01G is considered to have greater overall original cost estimating capability than
  - SEA 06
  - SEA 04
  - NAVELEX
  - NAVSEC
  - MSC
  - OP96
- NAVAIR and NAVFAC are considered to be somewhat superior to NAVSEA in overall capability to do their assigned basic estimating tasks.

- The Army (DARCOM), in the case of the XM1 Tank project, appears to have superior CA/CE capability over NAVSEA.

- The shipyards are much superior to SEA 01G in capability to prepare engineering estimates.

- NAVAIR, NAVSEC, Army, CAIG, CNA, NAVELEX and the shipbuilding industry make greater use of the computer for data storage and estimating than SEA 01G.

- NAVAIR, Army, and the shipbuilding industry make extensive use of return costs as a basis for estimating while SEA 01G relies primarily on bid data.

- NAVSEA has the smallest CA/CE staff relative to the dollar volume of estimates and collateral duties than any of the other organizations that prepare budget estimates.

- The NAVSEA 01G estimating staff is at the GS 12 average level which is less than NAVAIR, Army, NAVSEC, CAIG, OP96, SEA 06, SEA 04 and MSC. It is about the same as NAVFAC but greater than the shipyards.

- NAVSEA 01G is the only CA/CE organization that has a comprehensive training program.

- NAVSEA 01G appears to be the only Government office, except NAVAIR, that does not depend heavily upon industry estimates as the primary source.

- All the DOD offices reviewed rely heavily on parametric estimating. The Army and NAVFAC also rely heavily on engineering estimates prepared by private industry.

- NAVSEA 01G data bank seem to lie midway among the organization reviewed. Those considered to have superior data banks are:

  - Shipyards
  - NAVELEX
  - NAVAIR
  - Army

Those who have less are:

- OP96
- CAIG
- CNA
- MSC
- SEA 06
- NAVSEC

. NAVSEA 01G is required each year to estimate more new products in dollar value each year than any other SYSCOM.

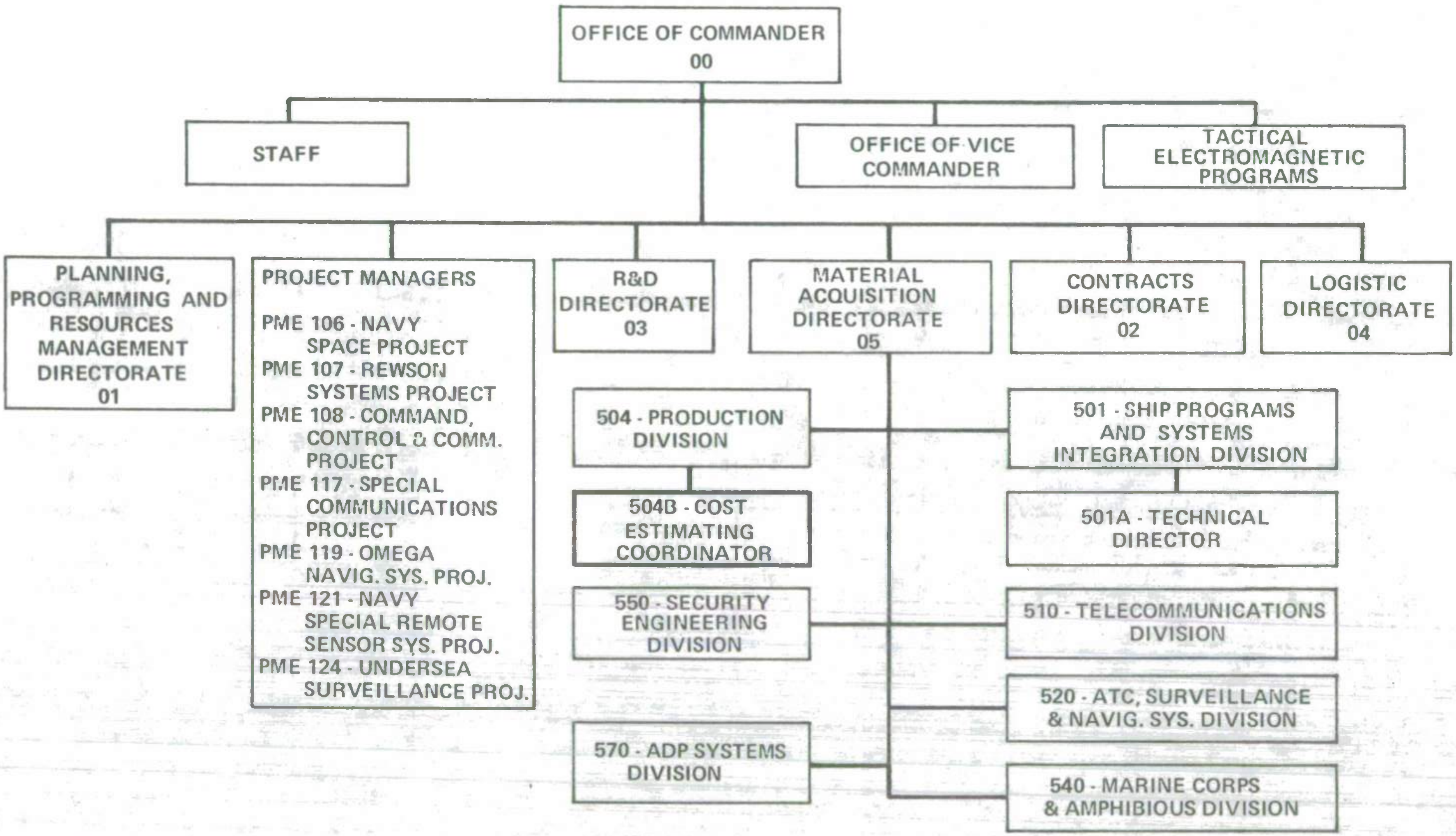
2. IN 1975, NAVELEX ESTABLISHED GREATLY EXPANDED COST ESTIMATING AND COST ANALYSIS PROGRAMS

NAVELEX is the Navy SYSCOM that has cognizance over a wide range of electronic systems, from radar to electronic counter measures. NAVELEX has a major input into SCN budgets for shipboard electronics and for FY 1977, the value of equipment procured over which NAVELEX has cognizance is about $100,000,000.

(1) The Cost Analysis/Estimating Program Establishes One Focal Point For This Function Within The Command

Within NAVELEX, Code 504B has been designated as the single cost analysis and estimating focal point. It is identified as the Cost Analysis/Estimating Group (CA/EG) and is responsible for all cost analysis and estimating policy and guidance. The CA/EG prepares and reviews cost estimates which are the basis for Command planning, programming, budgeting, and acquisition in research development,

FIGURE D. 23
NAVELEX ORGANIZATION



and production of equipments/systems. The CA/EG also performs technical cost analysis to evaluate proposals for accuracy and completeness and implements Command responsibilities in the special initiatives of Cost/Schedule Control Systems Criteria, Design To Cost, Life Cycle Cost, Economic Analysis/Program Evaluation, and training for cost analysis and estimating.

Figure D-23 shows the location of NAVELEX 504B in relation to Commander NAVELEX and the Project Manager.

(2) The Policy For Estimate Formulation Review Covers Many Cost Related Functions

The policy and responsibilities for all cost analysis and estimating functions performed by the Command includes the following initiatives:

- Cost estimates for POM/budget and DCP/DSARC submissions, Life Cycle Cost (LCC), Design-to-Cost (DTC), Foreign Military Sales (FMS), Advance Procurement Plans (APP), and Ship Project Directives (SPD).

- Cost analysis of direction costs presented in contractors' proposals to establish a fair and reasonable basis for contract negotiation.

- Implementation of Command responsibility for assuring Cost/Schedule Control Systems Criteria (C/SCSC) compliance in designated programs.

- Development and administration of training programs in cost analysis and estimating.

- Implementation of DTC and LCC goals in designated programs.

- Preparation of economic analysis and program evaluations to support selection of cost effective alternatives.

(3) <u>The Policy Sets Forth In A Logical Manner The Organizational Responsibilities With Respect To Each Of The Cost Related Functions</u>

The Cost Analysis/Estimating Group is responsible for all cost analysis and estimating policy guidance. For those programs which are managed by a designated Project/Acquisition Manager (PM/AM), the PM/AM shall have the ultimate responsibility for his program estimates. These estimates shall, however, be reviewed by the CA/EG, and any differences between the CA/EG and the PM/AM shall be resolved prior to release to higher authority. The principle policy statements are:

- Cost Estimating -- all cost estimates shall be documented by the originator, reviewed and certified by the CA/EG and authenticated at appropriate levels prior to release. Official Navy estimates, which include POM/budget and DCP/DSARC submissions, are reviewed and certified by CA/EG and submitted for authentication to COMNAVELEX or his designated Deputy Commander.

- Cost Analysis -- analysis of contractor proposed direct costs shall be provided in selected programs to support negotiations and contract awards at fair and reasonable prices. The CA/EG shall develop, implement, and maintain a high degree of capability for conducting the fact-finding and the analysis required.

- Design-to-Cost (DTC)/Life Cycle Cost (LCC) -- the Design-to-Cost concept establishes cost as a design parameter during a system's design and development phase. Cost requirements and the achievement of performance goals. DTC goals shall be established before program initiation (DSARC Milestone I for major programs) or at the earliest practical data thereafter, but in no case later than entry into full-scale development (DSARC Milestone II). The initial DTC goal shall be established as an average unit production cost related to a useable end-item of military hardware.

- Cost/Schedule Control Systems Criteria (C/SCSC) -- all acquisitions for major systems/equipments shall include contract requirements for implementation, demonstration, and application of management control systems. Accpetance of contractor's management control systems will be based on satisfactory demonstration of compliance with C/SCSC. Review teams established to evaluate contractor compliance with C/SCSC will be staffed principally from the CA/EG, the PM's office, and the cognizant DCAA office.

- Economic Analysis and Program Evaluation -- a systematic approach to the problem of choosing how to employ scarce resources by assessing the benefits and costs associated with various alternatives. Economic analysis is this approach when used to identify the best new/projects from a group of alternatives. Program evaluation involves trade-off studies for approved programs/projects to insure that established goals and objectives are being attained in the most cost-effective manner.

- Training -- regular training courses in cost estimating and analysis shall be scheduled and managed by the CA/EG to acquaint and inform NAVELEX, Navy and DOD personnel in cost estimating and analysis theory.

(4) Interview With NAVELEX 504B, The CA/EG Showed, In General, How The Policy Is Now Being Implemented

The Head of NAVELEX 504B stated that he was implementing the policy previously described. In order to implement the policy more

effectively, this group has recently completed the first phase of a computerized data bank which lists all NAVELEX contracts from 1969 to present. The volume shown contained complete contract information. The present data bank can be used for analogous type cost estimating and information can be entered and extracted by contract number. The next phase was completed in September 1977. The data bank information now can be extracted by electronic nomenclature (AN/) and contract number. So that the computer (data bank) can aid the cost analyst in cost estimating, data in the computer will give --

- what is new in configuration
- what are non-recurring costs
- inflation factors
- labor and material split

The next phase (completion date not known) will be in a format that cost trends that can be tracked by regression analysis.

There are seven people in the NAVELEX 504B office, only the Section Head having had Government cost estimating experience. The other six have had previous cost estimating experience in private industry. The NAVELEX 501A personnel conduct 70 percent of their business outside NAVELEX. It was stated that three people are on the road at all times keeping abreast of the various NAVELEX contractors, performing on site cost analysis as requested for OPNAV, NAVMAT,

and NAVAIR. The NAVELEX staff has been in existance only two years, are very young (GS 9-12) and most have had only one to one and one-half years allied experience in the industry. The Section Head was a member of the group that performed for NAVSEA an on-site cost analysis for the AN/SPS-49 Radar. He stated that in his opinion parametric estimates which are only accurate to $\pm$ 20 percent are a waste of time since engineering estimates with parametric comparisons are the best way to do costing. This can be done since NAVELEX equipments are always developed from previous designs with no more than 10 percent new features.

NAVELEX 504B has a unique relation to NAVELEX 02 (contract) with respect to the contract negotiation process. The Head of 504B participates in the contract negotiations but it is not clear if this is a prescribed responsibility or evolves from his personal relationship with contract negotiators. In preparation for negotiations, they prepare a detailed estimate. They were also instrumental in providing the NAVELEX contract negotiators with a 30 percent "cost realism factor" (margin).

The interview brought to light several interesting observations.

- NAVELEX 504B is of the opinion that SEA 01G operates in a vacuum so far as having close contact with the product manufacturer. NAVELEX 504B maintains very close contacts with manufacturers at top management level.

- Estimates are very sensitive to who the manufacturer will be and when the product will be manufactured.

- The budget estimate given by NAVELEX 504B to SEA 01G is based upon previous purchases of similar equipment, adjusted as they consider appropriate for the required time frame and number of units. NAVELEX will give SEA 01G estimates that include margins NAVELEX considers appropriate. (The details of these adjustments are not provided to SEA 01G.)

- Congress is one of the biggest problems due to program change, i.e., numbers of ships.

In summary, the major portion of time spent by NAVELEX 504B is in assistance to the contracting officer in placing new orders. It is in this respect that they visit manufacturers, examine his estimates in detail and do some estimating themselves. The budget preparation is of secondary importance and they make extensive use of previous contract data to check estimates prepared by the PMEs. The discussion did not indicate that much was being done in the areas of LCC, C/SCSC, DTC and economic analysis.

(5) NAVELEX 501A Is The Contact Point For Other SYSCOMS For POM/Budget Estimates Subject To CA/EG Review

NAVELEX 501A, Technical Director to the Ship Programs and Systems Integration Division, has cognizance over a number of equipments such as:

Radio Transmitters	AN/WRT-1A, AN/VRT-23 (V)
Power Supplies	PP-3916/UR, PP-2953/U
Antenna	AS-177B/UPX
Radio Transceiver	AN/URC-80VC, AN/SRC-20A
Radio Receivers	AN/SRR 19, AN/WRR-3B
Switching Unit	SA-1712/UR
Interconnection Boxes	J-2910/UR
Transponder Sets	AN/UPX-26
ECM Receiving Systems	AN/WLR-8
Magnetic Amplifiers	AM-1017/SLR
Omega Receivers	AN/SRN-12
Tacan	AN/SRN-( )
IFF Controls	C-6280/APX
UHF Channel Selector	C-3868/SRC
Frequency Standards	Cesium Beam
RF Amplifiers	AM-2123A
Multicoupler	AN/SRA-33

The Section Head stated that there was no NAVELEX instruction that specifically covers his group. He said his group did not follow any definite cost estimating procedures and that the staff does not consider themselves to be professional estimators, but this has been one of their important functions for about 15 years. It was clearly acknowledged

that NAVELEX 504B functions as the Command focal point and source of policy and procedures for cost estimates.

NAVELEX 501A, in most cases, costs are estimated for developed equipments from previous procurements. This Code has the Fleet Modernization Program and the Program Objective Memorandum (POM) Program. The group is the NAVELEX point of contact for other SYSCOMS, such as SEA 01G for the POM program, and provides what it considers to be budget quality class "C" estimates. It was noted that NAVELEX has the typical SCN funding problem -- for example, it estimates costs in 1977 for the equipment purchased in 1979; with delivery in 1981 or 1982.

For the POM programs, NAVELEX receives information from SEA 01 as to ships' requirements and the characteristics required by CNO. Normally, NAVSEC 6179 prepares the appropriate electronics list and forwards it to NAVELEX 501A. The cognizant systems/equipment engineers review the requirements and will make changes if the equipments listed have been replaced by newer designs. NAVELEX 501A will consider inflation factors, quantity, type of contract, and forward the POM cost estimates to SEA 01G via NAVELEX 504B for certification. This Code does not contact manufacturers during the course of estimate

preparation. If this is done, it is by NAVELEX 504B. SCN and FMP equipments are purchased on the same contract in order to receive better prices. NAVSEC has not prepared electronics lists for the last two years (FY 78 and 79), so NAVELEX 5103 may prepare the Command requirements for future POM programs. NAVELEX has approximately 80 percent of the equipments listed so this will be a significant estimating effort for NAVELEX.

The NAVELEX 501A's data bank is the contract files which go back quite a few years. It was stated that certification requirements by CNO and NAVMAT, and software have been large cost drivers. Another cost driver is the reduction in total number of ships. If less equipment is required which reduces size of the orders the expected savings are lost.

(6) NAVELEX PME 107, Rewson System Project, Was Selected For Review To Determine Just Where Equipment Estimates Originate

From the previous interview it became apparent that cost estimates were coming out of project offices, principally from engineers who are dealing with contractors and manufacturers on a day-to-day basis.

PME 107, Rewson System Project, prepares estimates for a number of equipments which are considered typical with respect to cost estima-

ting procedures. PME 107F is responsible for Electronic Counter Measure Systems (EMC). PME 107F13 is the budget office within the PME and is responsible for the SCN cost estimates which NAVELEX furnishes SEA 01G for the POM Budget process. They receive guidance from NAVSEA 012 as to ships in the forthcoming Five Year Defense Plan and the single sheet characteristics for applicable equipments. PME 107F13 will distribute the ship ECM equipment requirements to the cognizant engineers within PME 107. Most of the equipments are repeat buys.

Cost estimates are not provided with cost classifications. Contracts are mostly sole source in order to keep the number of constractors making sensitive electronic counter measures small as a matter of security. Contracts include hardware, spare parts, and engineering services. PME has same problems as other NAVSYSCOM estimators. For example, cost estimates are put together in FY 77, funds are received in FY 79, and equipments are not delivered until FY 81 or 82.

The PME 107F group is staffed as follows:

	Grade	Estimating Years Experience
Section Head	GS 14	14 years electronics; 3 years budget analyst
Budget Analyst	GS 12	
Budget Analyst	GS 12	
Financial Manager	GS 13	
Budget Analyst	GS 12	

PME 107F is responsible for SCN, OM&N, and RDT&E cost estimates. It does not perform cost estimating, but rather the engineers who are in change of individual equipments actually provide the cost estimates.

The cost estimates are based on previous contracts or equipment vendor quotes. In some cases, VITRO Corp., a private contractor, will provide cost estimates. These cost estimates are forwarded to PM 107F13 where appropriate inflation factors are added based on the DOD inflation indices. Past Ship Project Directives are the only data base (bank) in PME 107F.

The PME 107F13 estimates are reviewed by PME 107F and then forwarded to NAVELEX 501A for inclusion in the NAVELEX POM cost estimate package which is forwarded to SEA 01G. There is no independent cost estimate performed by other NAVELEX groups nor is certification usually given by NAVELEX 504B.

The major GFM cost growth factor is caused by the many engineering changes to the original equipment between the time a budget estimate is made and the time equipment is procured. It was stated that there has also been growth (overruns) in the engineering services, program support, and peripheral equipment due to increased labor rates.

(7) <u>NAVELEX PME 107-1 For The AN/WLR-8 Has A Contractor Prepare Cost Estimates</u>

NAVELEX PME 107-1 is the Project Engineer for the AN/WLR-8 a submarine electronic counter measures system. This is a one-man office which relies heavily on contractor support. Systems Consultants, Inc. (SCI) works closely with PME 107-1 with added support from the home office. SCI does engineering type of work for PME 107-1, but they do assist in the PME 107-1 cost estimating for major changes to the AN/WLR-8. In addition, they provide required assistance for Integrated Logistic Support (ILS) and documentation. SCI is made up mostly of engineers but has many logistic types.

For procurement cycle, PME 107-1 maintains close liaison with PMS 393 (SSN 688) and PMS 396 (Trident) for Ship Project Directives (SPDs) and provides the dollar amounts that PMS 107 will require to purchase the AN/WLR-8. PMS 396 and PMS 393 have standard check lists when pricing out equipments for their ships and have also provided PME 107-1 with inflation factors.

The first contract for the AN/WLR-8 was a cost plus fixed fee, awarded in January 1971, so a substantial cost history is available to help in the cost estimating process for the POM SCN budget. PME 107-1 also receives help from NAVELEX 504B to perform price analysis

at the manufacturer's plant and can also call on the Defense Contract Audit Agency (DCAA) for audits. It was stated that the local Defense Contract Administration Services (DCAS) can also be called on to audit the contractor's performance.

For this Code, cost estimating is relatively simple, being concerned with a standard piece of equipment with six years procurement history.

(8) NAVELEX PME 107-3 Is A Design-To-Price Project Office For The "Anti-Ship Missile Defense Electronic Warfare System Project"

This project is for a new system which is composed of many "state of the art" components and is one of the first "Design-to-Price" projects. It is called the "Anti-Ship Missile Defense Electronic Warfare (EW) System Project -- AN/SLQ-32. This equipment comes in three versions with varying capability. The V-1 is a simple system which can detect missiles and provide threat warning. The V-2 includes all of the V-1 capabilities, plus wider frequency coverage and Identification Friend of Foe (IFF) capability. Finally the V-3 has all the V-1 and V-2 functions, plus provisions for Electronic Counter Measures (ECM). The V-3 model is to be installed on larger combatant ships like the CGN 42 and 43, and possibly the DDG 47 class.

The initial Design-to-Price (DTP) cost thresholds of $300,000 for the V-1, $500,000 for the V-2 and $1,500,000 for the V-3 were established by OPNAV. An invitation for bid went out to the electronic industry with general guidance provided by NAVELEX as to what was required and the shipboard interfaces expected. The system had to be built around known techniques and it was not to exceed the above cost thresholds. While 72 companies expressed interest, only 12 were selected to submit proposals. Eventually, this was narrowed down to six (6) companies who submitted their ideas as to what could be developed for the price set by the Navy.

The selection process was very involved. The six proposals were evaluated by a Navy team with personnel from NAVELEX, OP96, NAVMAT, Navy Laboratories, NAVSEA 06 and the Navy Electronics Laboratory Center. The RCA Cost Predicition Computer Model developed by RCA Moorestown was used to evaluate the six proposals and then the final two. RCA trained OP 96 cost estimators in the use of the cost model (PRICE).

In October 1973, contracts were signed to build two pre-production models, one with Raytheon for the AN/SLQ-32 design and one with Hughes for the AN/SLQ-31 design. The contractors provided PME 107 cost information as the pre-production models were being built.

Raytheon and Hughes could make changes to the design provided the general requirements set forth by NAVELEX were followed and that the cost thresholds were not exceeded.

The initial cost thresholds were for the hardware plus spares and installation; included was a projected inflation rate of three percent annually for the period August 1973 - August 1975. The actual inflation during this period was 25 percent. The total price, however, remained the same, but the performance capability of the pre-production models had to be reduced to keep within the DTP limits. The equipments were built and installed side by side on the U.S.S. LEAHY where they went through an evaluation. The Raytheon design, the AN/SLQ-32, was finally selected.

During the negotiations, substantial amounts have been saved by detailed proposal reviews. Both the Raytheon's and Hughes' designs went through DSARC I and II simultaneously. NAVELEX 504B was involved in the DSARC II proposals, financial management, and selection phases. As a result of the NAVELEX participation, the labor rates proposed by Raytheon were reduced and the total cost of the AN/SLQ-32 contract was reduced $20 million. Raytheon had proposed labor rates based on the experienced types that they presently employ. NAVELEX 504B proved that most of the people they hire start at a much lower

salary and thus the savings.

PME 107-3 is typical of the Navy Department Participating Managers (PARM) in that cost estimating is secondary to their function as equipment designers and/or procurement, and there are no professional cost estimators in the organization. The staff consists of:

- Military -- one captian and lieutenanct (Navy)
- Civilian -- six, ranging from GS 15 to 12

The group has one (1) Electronic Engineer from the Naval Research Laboratory (NRL) assigned full time to the AN/SLQ-32 project but the project will eventually be assigned four (4) more engineers. For cost estimates the group relies heavily on contractor information or on NAVELEX 504B.

The contract with Raytheon is a fixed price incentive with projected inflation. The Program Objectives Memorandum (budget) process for the AN/SLQ-32 would be the same as previously described earlier on PME 107F13. It was stated that Design-To-Price has to be done competitively right down to the point where two equipments are evaluated under similar conditions. Without compeition, the AN/SLQ-32 thresholds would not have been maintained according to PME 107-3.

The concept of building two pre-production models was first used by the National Air and Space Agency (NASA). The approach should be used more in those cases where the kind of hardware required can be described; when approaches to the design can be defined for the bidder; when the reliability and maintainability requirements can be identified and when a realistic cost threshold can be determined.

(9) Conclusions

It would appear from the depth of review allowed in this study that the following conclusions can be drawn.

- Almost all estimates originate with contractors or manufacturers
- The POM/Budget estimates draw heavily on prior purchases adjusted for expected inflation, size of buy, possible changes, etc.
- Documentation of SCN POM/Budget estimates provided to SEA 01G is incomplete
- NAVELEX 504B is, in fact, the estimating focal point in NAVELEX and has a substantial input to budget estimates, as well as the actual contractor selection and contract negotiations.
- NAVELEX has only five personnel officially designated as estimators.
- Cost drivers between time of Budget and Acquisition are:
  - inflation
  - program change
  - upgraded specs
  - scope

3. NAVAIR HAS A FISCAL RESPONSIBILITY VERY SIMILAR TO NAVSEA BUT THE ACQUISITION CIRCUMSTANCES ARE DIFFERENT

NAVAIR has the same budgeting and acquisition responsibilities with respect to Naval aircraft and missiles as NAVSEA has with respect to ships. The budget for aircraft and missiles is about $5.0 billion for FY 1978.

The cost estimating and budget formulation process, though similar to ships, has some unique characteristics of its own that should be considered.

- The naval aircraft are unique in that the new programs are always incorporating features and requirements that crowd or exceed the current technological threshold. This leads to difficult cost prediction.
- Number of units produced each year are ten to twenty times more than naval ships.
- The aircraft industry is very sensitive to program changes with regard to numbers and technical change.
- There are sufficient sole source equipment suppliers whose performance can have an important impact on aircraft production for a number of prime contractors.
- A change in one aircraft program could effect the costs in another. For example, if two aircraft programs were to use the same engine, the engine cost would reflect a purchase of so many engines. If one program was canceled, the unit engine cost would then increase on the aircraft in the remaining program.
- Navy is buying a manufacturer's design to meet given performance requirements.
- Compeition between aircraft manufacturers is based on both design and cost.

(1) NAVAIR Has Four Codes That Make A Substantial Contribution To Aircraft And Missile Cost Estimates

Figure D-24 is a basic organization diagram showing the position of NAVAIR 506 and other cost estimating codes in the NAVAIR Command. The Evaluation Division (NAVAIR 506) estimates the "flyaway cost", except for engines which are costed out by NAVAIR 536 (Propulsion Division). Ground support costs are estimated by NAVAIR 534. Such elements as Peculiar Training Equipment, publications, and training facilities and spare parts are provided by NAVAIR 410 (Logistics Management Division).

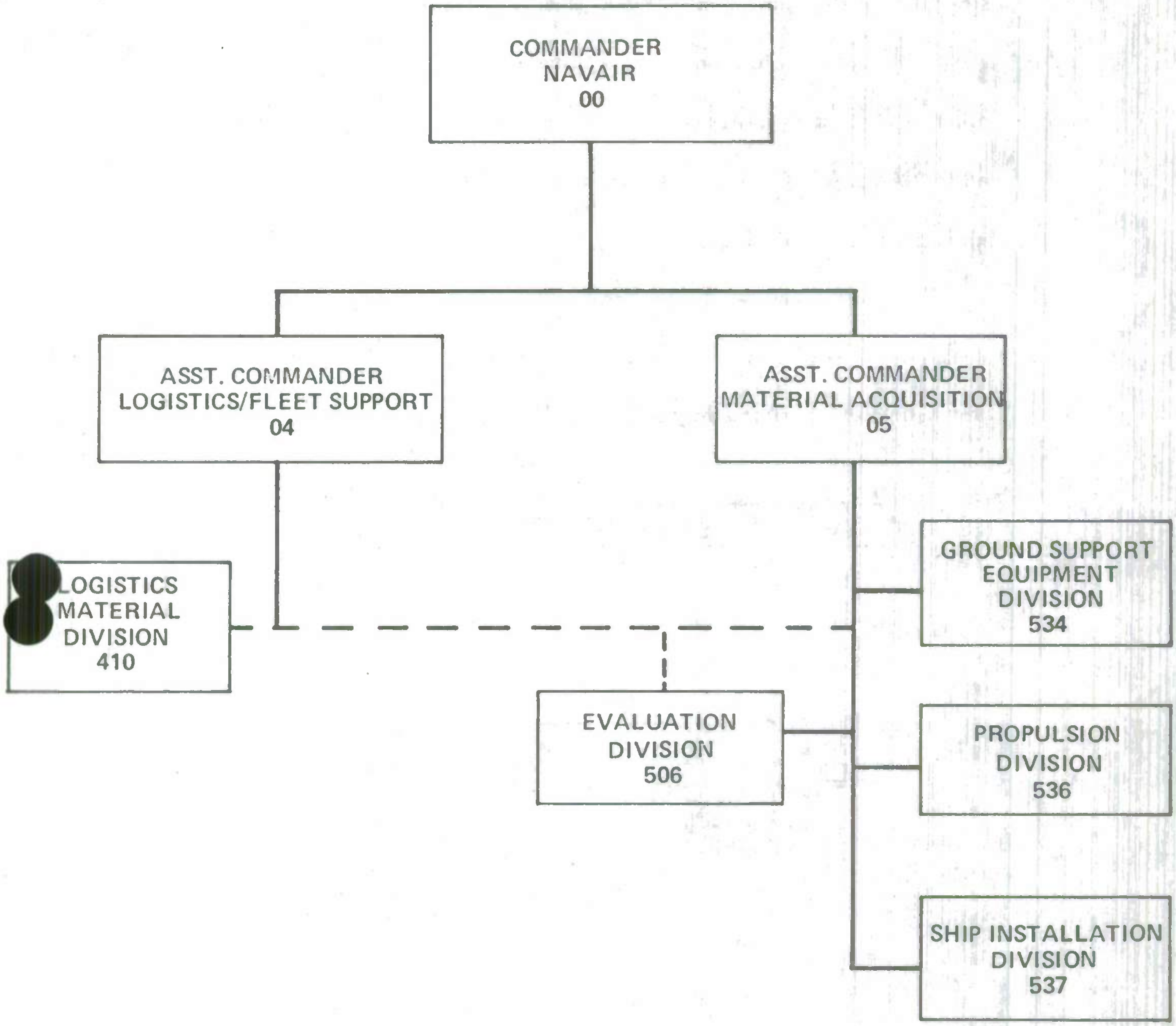
(2) NAVAIR 506 (Evaluation Division) Is The Cost Estimating Focal Point For NAVAIR

NAVAIR 506 puts all these inputs together, validates the estimates and provides this to the aircraft project manager for budget submission. This is the same procedure that is followed in NAVSEA. As the estimating focal point, NAVAIR 506 is called upon to provide technical and financial justification for all of the elements making up the investment cost.

NAVAIR 537 (Ship Installations Division) estimates the cost of aircraft support equipment going aboard ships as GFM in the SCN budget.

FIGURE D.24

NAVAIR ORGANIZATION (BASIC)



NAVAIR 537B is part of the NAVAIR Ship Installation Division 537 with primary duties in the planning and programming for the installation of shipboard NAVAIR equipment. Two people make up this group. In addition to plans and programs, NAVAIR 537B acts as the point of contact for all NAVAIR SCN equipment cost estimates forwarded to NAVSEA 01G for the POM programs. NAVAIR 537B has the responsibility of furnishing catapaults, arresting gear, and visual landing aid systems for carriers. It is supported by a 27 man field activity that does the cost estimating for the above equipments. No independent cost estimate is performed by other NAVAIR groups.

(3) NAVAIR Parametric Cost Estimating Techniques Develop The Twenty-Five Elements In The "Investment Cost"

The cost model elements in the "Investment Cost" are as follows:

PROGRAM ITEM

Aircraft	Missile Hardware
Airframes/CFE	G, C and A
Changes Allowance	Propulsion
Engines	Booster
Engine Accessories	Safety & Arm. Mech.
Electronics	Target Det. Device
Armament	Warhead
Other GFE	Integration and Assy.
Non-recurring Cost	Engineering Changes

Flyaway Cost
- Air Frame PGSE
- Engine PGSE
- Avionics PGSE
- Peculiar Training Equipment
- Pubs/Technical Data
- Fac. Training/Training Parts

Support Cost
- Gross P-1 Cost
- Advance Procurement (credit)
- Advance Procurement

Program Cost
- Spares/Spare Parts

Capital Investment Cost

Procurement Support
- Sys. Engr./Proj. Mgt.
  - Contractor
  - Gov't-in-house
- Special Tool & Test Equip.
- Inspection Gages
- Gov't. Test Program
- Data
- Containers

Fleet Support
- Peculiar Spt. Equipment
  - Test Equipment
  - Handling Equipment
- Training Equipment
- Training Services
- I.L.S. Data and Pub.
- I.L.S.

A substantial portion of the NAVAIR budget is follow-on aircraft and missiles which do not require new estimates from the ground-up. The variables for follow-on equipment are usually related to the number ordered, changes in electronics, armament support activities, inflation, overhead, etc.

With new equipment, it is necessary to use all information available to build up to the Investment Cost. The system now in use, however, calculates the entire airframe as one number using parameters of weight, complexity, material, special features, etc. The estimating procedure is not broken down however, so cost for fuselage, wings, tail assembly or landing gear cannot be estimated individually. Although

return cost data can be purchased in this detail, the various Project Managers do not consider it worth the expense. They do receive aggregate return costs for plant-wide labor, overhead, etc., according to the CCDR requirements.

With the use of the computer, CERs are developed for other elements in the Investment Cost. They use OSD guidance for out-year inflation by using their own factors for budget year estimates because they consider the OSD values to be low.

NAVAIR 506 has direct contact with manufacturers and, as a result, can form an opinion as to market conditions, inflation factors, learning curve, productivity, etc.

The estimating process at all levels of confidence is primarily parametric, with extensive use of the computer.

- During conceptual design, NAVAIR will use a Rand cost model to arrive at a "rough estimate". These estimates are usually LCC cost exercises which are used to evaluate the cost of various characteristics on weapon trade-off studies.

  NAVAIR 506 also uses its own computer -- a Hewlett Packard System Model 9830. This system stores the databank and has the ability to process this data by using multiple linear regression analysis so cost of similar elements can be estimated by using weights and the degree of complexity as the principle parameters.

- The Budget estimating is done by the same group with the assistance of other Codes mentioned earlier. Note was made during the interview that the learning curve for aircraft is much less apparent or predictable since the numbers of aircraft ordered have dropped from 3,000 in the 60's to 300 currently.

- NAVAIR 506 does not prepare a contract estimate prior to award nor do they perform a TAR prior to award.

(4) NAVAIR Estimating Resources Are Similar To NAVSEA With Some Substantial Differences

Approximately 50-60 people throughout NAVAIR contribute to the cost estimating and analysis function. The largest group is NAVAIR 506 with 30 people, NAVAIR 536 with eight and twelve in NAVAIR 534. The remaining five to ten are distributed among various Codes, such as NAVAIR 410 and 537.

- In NAVAIR 506, the personnel are on the average young, well-educated and hold good civil service grades. The average age is 35. Ninety hold one or more degrees in business, mathematics, accounting, economics, etc. The staff has no engineers and very little industry experience outside of government. The range of experience for most of the staff in cost estimating or analysis is five to ten years.

- NAVAIR makes little use of outside contractors for direct estimating services; NAVAIR 506 only uses outside help to do computer programming. The computer is physically in house and operated by NAVAIR personnel.

- The data bank in NAVAIR is fed primarily from CCDR which is stored and processed in the computer. The data bank is being fed new data continually and programs are also being continually revised and improved.

- Technical data is provided as required by NAVAIR Project Managers, engineering codes, and vendors. This is the source of physical parameters used in the estimates.

(5) <u>NAVAIR's Input To The SCN Budget Comes Through NAVAIR 537 -- Ship Installation Division</u>

NAVAIR 537B is part of the NAVAIR Ship Installation Division 537 with primary duties in the planning and programming for the installation of shipboard NAVAIR equipment. Two people make up this group. In addition to plans and programs, NAVAIR 537 B acts as the point of contact for all NAVAIR SCN equipment cost estimates forwarded to NAVSEA 01G for the POM programs. NAVAIR 537B has the responsibility of furnishing catapults, arresting gear, and visual landing aid systems for carriers. It is supported by a 27 man field activity that does the cost estimating for the above equipments.

- The Head of 537B is a GS 14, the only professional in NAVAIR 537 B. He has had approximately 15 years government experience and ten years experience in private industry.

- The actual estimates are provided by engineers in the field activities (27 men) using former contracts as the data base (bank). All the equipments furnished by NAVAIR 537B have been contracted for many times. There is no pricing group in the field units only engineers doing cost estimating. Contracts for parts and some services are the source for the catapults material cost since the only manufacturer is the Naval Engineering Center, Lakehurst, a government facility. Contracts for other equipments furnished by NAVAIR 537 are competitive. For all equipments they will add inflation factors based on Department of Defense indices.

It was stated that most of the cost estimating done for NAVAIR 537 equipment is not scientific but based on experience.

- The only cost estimate review is by NAVAIR 537 at headquarters for selected equipments. No independent cost review is performed by any outside activity. The opinion was expressed that major cost drivers were the material cost increase, labor rate increase, and inflation. Once a contract has been given for equipment, almost no change takes place. Occasionally, some Engineering Change Proposals are forwarded by fleet units for safety or corrosive reasons. There are no GFM integration problems.

(6) Aircraft Prices Have Gone Up Dramatically Since 1960

In broad terms, cost for aircraft has gone up ten times in the last 15 to 20 years. The principle causes for this increase have been:

- Inflation
- Technical sophistication
- Reduced numbers
- Decreased productivity

4. NAVFAC IS RESPONSIBLE FOR A WIDE RANGE OF FACILITY INSTALLATIONS AND DOES A MAJOR PORTION OF ITS COST ESTIMATING IN THE FIELD

The Naval Facilities Engineering Command (NAVFAC) is responsible for the construction and maintenance of all Navy shore installations and facilities. The annual new construction budget for 1977 is $600,000,000 for which the approximate average cost per project is $2,000,000. The largest project in the FY 1977 budget is for a hospital at an estimated cost of $23,850,000.

NAVFAC projects, in most instances, are closely allied to similar projects found in the commerical world. Naval Facilities include airports, housing, shops, office buildings, hospitals, schools, research centers, test facilities, ammunition stowage, piers, wharfs, etc.

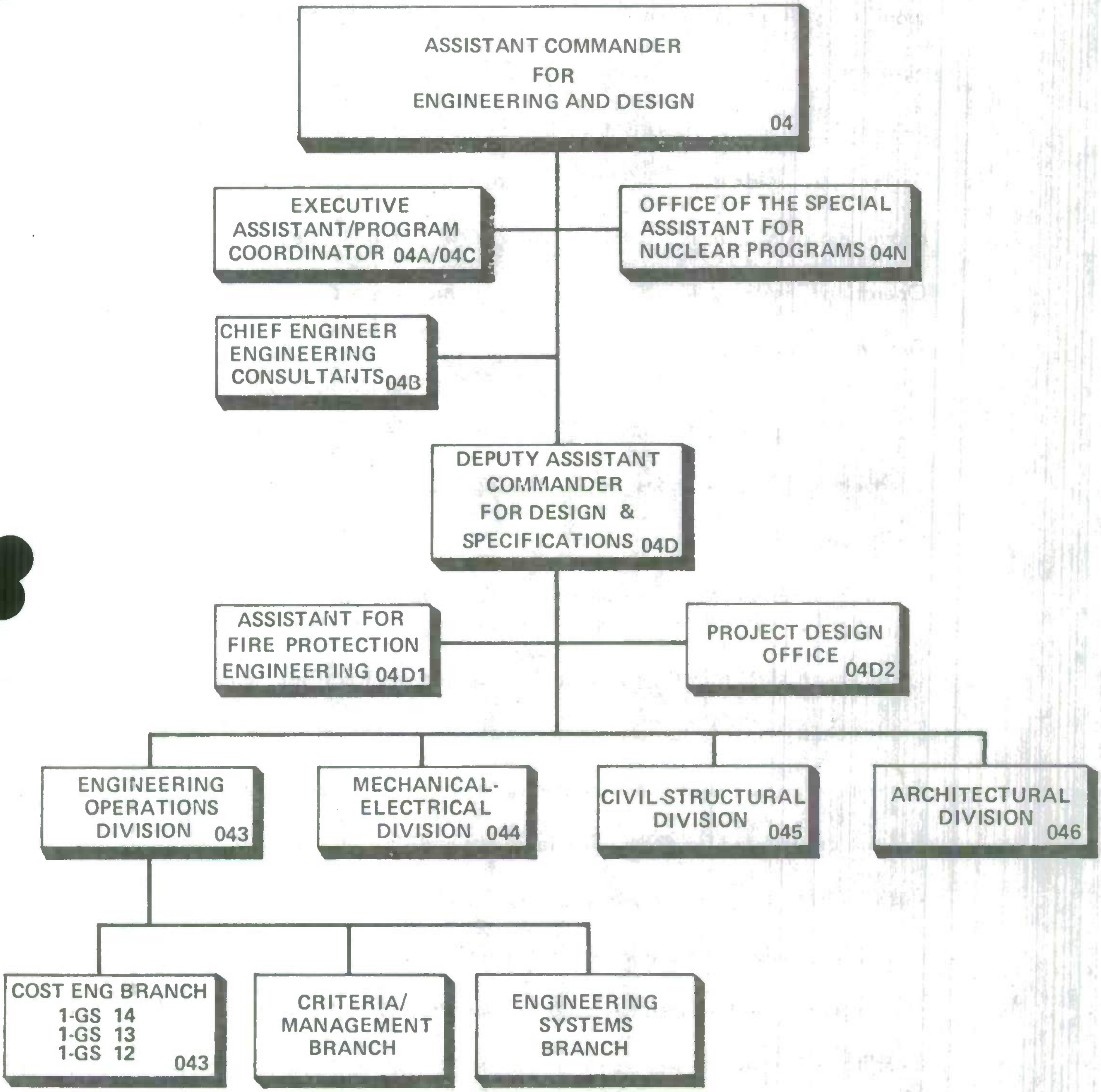
In contrast to weapons or ships, which are manufactured in large number (weapons) and ships where design similarity is a goal, most of the shore installations are one of a kind and must be estimated and contracted for on an individual basis over a widely dispersed geographical area. In order to facilitate timely, knowledgable estimating on those projects where cost varies with the locality, the estimating is done in the field.

(1) The Headquarters Office Gives Estimating Guidance, But The Estimates Are Prepared In The Field

Figure D-25 shows the relationship of the estimating organization in headquarters to the Assistant Commander for Engineering and

FIGURE D.25

NAVFAC HEADQUARTERS ORGANIZATION



Design. The Naval Facilities Engineering Command has the lead responsibility for project planning, military installation planning and civil engineering; and to conduct shore facilities planning for all components of the Navy and others as directed. The administration for the Engineering Field Divisions (EFD) that provides cost estimates for the above responsibilities is located in NAVFAC 043, the Engineering Operations Division, which is part of the Engineering and Design Command (NAVFAC 04).

There is no cost estimating being done in NAVFAC headquarters although NAVFAC 043 does provide costing guidance for the EFD by the issuance of:

"Conceptual Military Construction Cost Engineering Data" and
"Historical Military Construction Cost Engineering Data"

The conceptual data is the basis for the preparation of cost estimates and budgetary costs in the conceptual or planning stage for Public Works Construction. The costs are presented at the engineering estimate level and can be adjusted for geographic locations and time element. The Historical Military Construction Cost Engineering Data provides information for the review of the related FY Military Construction Programs by fiscal year . This document lists the cost forprojects at the time and location of award.

The responsibility for preparing the budget and engineering estimates for the construction program is assigned to Engineering Field Divisions listed below.

- Atlantic Division - Norfolk, Virginia
- Chesapeake Division - Washington, D.C.
- West Division - San Francisco, California
- North Division - Philadelphia, Pennsylvania
- South Division - Charleston, South Carolina
- Pacific Division - Honolulu, Hawaii

The staffing of these offices for estimate preparation or review of estimates prepared by outside architectural and engineering firms is as follows:

Division	Number	GS Grade Range
Atlantic Division	15	13-11
Chesapeake Division	5	13-11
West Division	17	13-9
North Division	8	13-11
South Division	6	13-11
Pacific Division	4	13-12
Total	55	

Although the EFDs are responsible for estimate preparation, most of the estimates are made by outside Architectural and Engineering firms (A&E).

(2) New Procedures Require Budget Estimates Be Based Upon The Design Being 30 Percent Complete

The budgeting process begins with the preparation of the Basic Facilities Requirement List (BFRL). The BFRL lists the essential facilities for an activity to perform its mission, tasks, function, and workload. The activity Commanding Officer (CO) is responsible through the Major Claimant for planning, funding, and sponsorship of construction. Major Claimants are those commands, bureaus, and offices designated by the CNO, as claimants for a share of Military Construction programs for the shore (field) activities under their command.

Annually in July, the Military Construction Review Board (MCRB) will meet to discuss the list of priorities and made adjustments to the BFRL. For approved projects, the facility prepares DD Form 1391, (Figure D-25A) Military Construction Project Data, which are submitted for the next annual Military Construction (MILCON) program. The CO provides narrative and justification data and the EFD provides technical engineering services and data in support of the project. Form 1391 provides cost estimates for the primary and supporting facilities for unit cost and total cost and provides a five percent contingency for the project. This form is the primary document used for processing a MILCON project through the various review levels of the Department of the Navy, Department of Defense and for submission to the Congress for funding.

FIGURE D.25A

1. COMPONENT	FY 19__ MILITARY CONSTRUCTION PROJECT DATA	2. DATE

3. INSTALLATION AND LOCATION	4. PROJECT TITLE

5. PROGRAM ELEMENT	6. CATEGORY CODE	7. PROJECT NUMBER	8. PROJECT COST ($000)

9. COST ESTIMATES

ITEM	U/M	QUANTITY	UNIT COST	COST ($000)

10. DESCRIPTION OF PROPOSED CONSTRUCTION

DD FORM 1 DEC 76 1391

PREVIOUS EDITIONS MAY BE USED INTERNALLY UNTIL EXHAUSTED

PAGE NO

FIGURE D.25A (continued)

1. COMPONENT	FY 19__ MILITARY CONSTRUCTION PROJECT DATA	2. DATE
3. INSTALLATION AND LOCATION		
4. PROJECT TITLE		5. PROJECT NUMBER

DD FORM 1 DEC 76 1391c

PREVIOUS EDITIONS MAY BE USED INTERNALLY UNTIL EXHAUSTED

PAGE NO.

The current requirement as set forth in NAVFACINST 11010.14C (11 November 1975) is that Form 1391 must reflect 30 percent design as defined in Exhibit D.5. This design effort is funded out of current year monies made available for this purpose, which amounts to 4.5 percent of the total program costs.

The design and estimating work is usually contracted out as soon as the project has been approved. The 30 percent design is then to be finished in time to complete DD Form 1391 for the budget process. At the 30 percent design stage, the cost estimate is considered to be accurate within 10-20 percent. The responsible EFD reviews the 30 percent design and costs; resolves differences with the CO/A&NE; and aids in the preparation of DD Form 1391. The design effort continues with the goal to have a 100 percent design and a final estimate about six months before the President's Budget is presented to Congress. This also gives NAVFAC about two or three months to adjust the programs before they become locked in.

(3) Most Of The Estimating Is Done By Architectural And Engineering Firms

The rule of thumb division of design and estimating work is 25 percent for the Navy field office and 75 percent for the A&E firms. All of the work done by the contractors is reviewed and checked by the

field office.

The cost estimating procedures are those commonly used in industry. Substantial use is made of published data, handbook and contract award data. The Navy does not receive return costs as a general rule as all projects are awarded on a fixed price basis.

NAVFAC has worked from time to time on greater computer use in estimating. Three years ago, NAVFAC 043 developed a computer cost estimating format and data bank which was not accepted by the field divisions. They are presently in the process of revising the cost estimating computer format and this time NAVFAC 043 has inputs from the field divisions incorporated into the new system. A uniform work breakdown structure (WBS) is being used for the computer data bank. The new system will have terminals in each of the EFD's and the new format (system) will have the capability of sorting out the various data codes and has 99 indicators programmed for updating the data base. Some of the stored data is the same for all the field activities but in certain cases there are different columns of data for each of the EFD's. The system will go into use very soon, however, the use of the system by the EFD's cannot be legislated by Headquarters but it is hoped that it will have wide use.

The detail of the budget estimate which backs up the DD Form 1391 can vary from the very abreviated breakdown shown on DD Form 1391 to a detailed bottom-up estimate of 10-50 sheets with several hundred line items. The 100 percent estimate examined was for a hospital. This estimate consisted of 128 sheets and approximately 2,000 line items.

The budget estimates prepared by NAVFAC have a five percent margin. This cannot be exceeded. If the 100 percent estimate indicated this margin would be exceeded, the scope of the project is reduced or it is postponed for re-evaluation in a following year.

(4) Qualifications For Estimators Stress Practical Experience

The total number of estimators in the field is about 55, ranging from GS 13 to GS 9. These estimators, for the most part, are not college graduates but have worked in the construction industry and know the business from the practical side. At the Chesapeake Division, the head cost estimator has had approximately 30 years experience and the others have had five, six, nine, and ten years cost estimating experience, respectively.

(5) <u>NAVFAC Procurement Procedures Greatly Reduce Chances For Cost Overruns And Cost Growth</u>

If the 30 percent design criteria is enforced, the chance of cost overruns will be greatly reduced if inflation factors can be reasonably predicted. This is possible only because the design has advanced to the point where the Navy is reasonably sure of what the project requires.

(6) <u>NAVFAC Cost Estimate Review Procedure Is Practical And Straight Forward</u>

As mentioned earlier, the estimate review is made in headquarters by NAVFAC 043. This office reviews the estimate for content and compliance with current directives and policies. The detailed costs are checked against general cost parameters for similar work and market expectations. NAVFAC does not prepare Independent Cost Estimates using Operations Research-type techniques used by the Army or parametric analysis used by NAVAIR, the CAIG and OP96D.

(7) <u>Cost Drivers For Shore Facilities Are Generally Limited To Inflation</u>

NAVFAC's contracting and specification requirements closely parallel commerical, civilian public works and projects. The firming up of design prior to budget submittal and the dictated five percent

growth limitation has almost eliminated cost growth except for unexpected inflation. The unexpected inflation from 1973 to 1976 did catch NAV-FAC unaware, as it did everybody else. Now, however, they are finding that estimates made one year ago include an allowance for inflation and market which is in excess of what is now being experienced.

5. THE MILITARY SEALIFT COMMAND (MSC) HAS AN ESTIMATING CAPABILITY ASSOCIATED WITH THEIR ENGINEERING OFFICE

The MSC operates very much like a large private shipping company, with 89 ships serving a variety of roles from ordinary cargo transport to complex oceanographic duties.

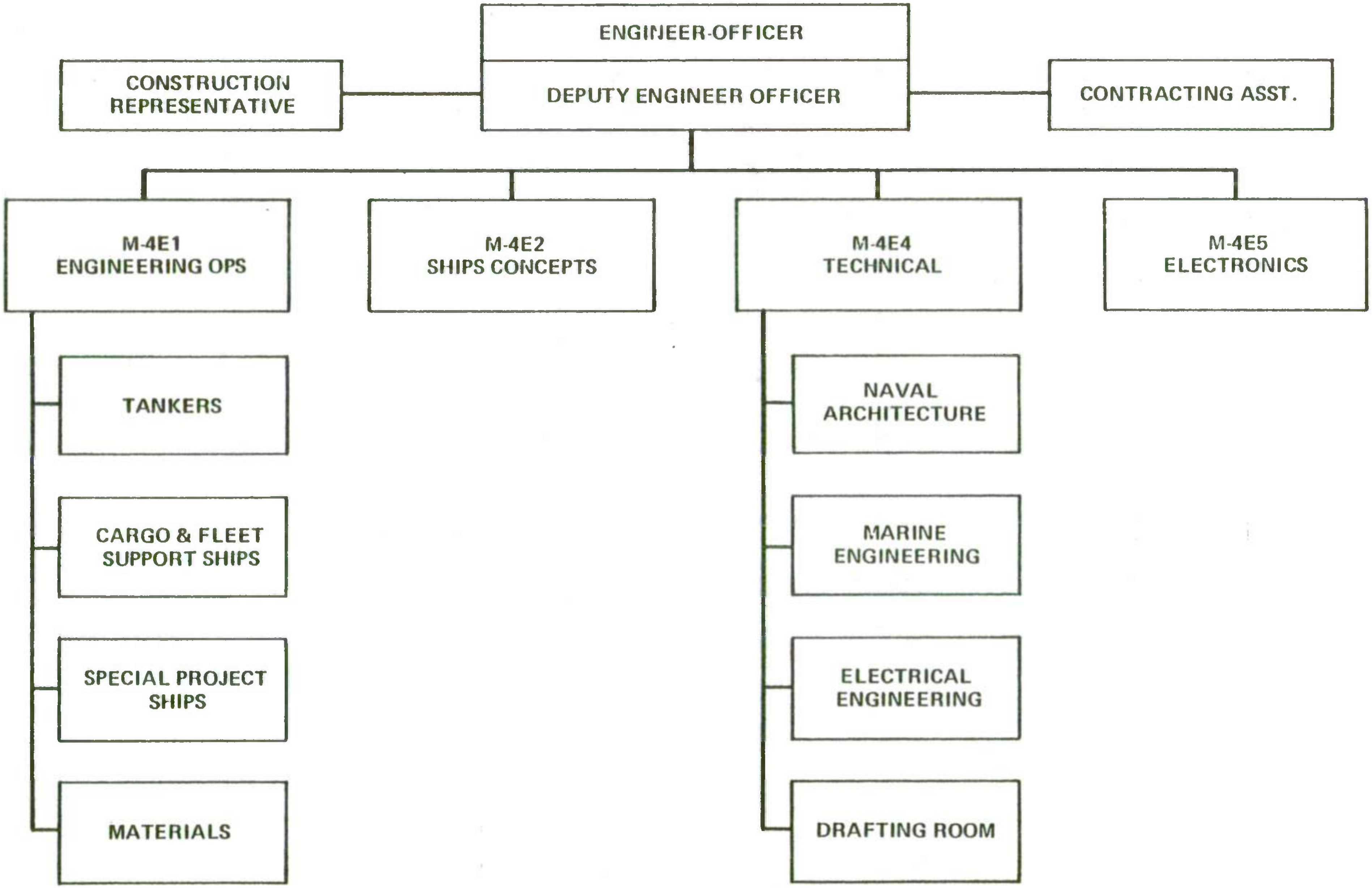
The Military Sealift Command Engineering Office is responsible for the engineering operations, maintenance, repairs, and alterations of the MSC fleet and such special project ships as are assigned to it. This includes planning, supervising and approving the development, construction and conversion of ships to be operated by MSC, and supervising the Technical Materials Program of MSC.

(1) The Ships Concepts Division Has The New Ship Construction Cost Estimating Capability Within MSC As A Secondary Function

The organization of Headquarters staff of Engineering Officer is shown of Figure D.26. The cost estimating function is carried out in

FIGURE D.26

MSC HEADQUARTERS STAFF-ENGINEERING ORGANIZATION



Code M4E2 -- Ships Concepts Division.

The Division was formally established in 1967. This Division provides a focal point for defining MSC requirements for new ships. The Division is also concerned with developing ship characteristics and designs in support of MSC programs and plans and with providing naval architectural information on new concepts and advanced ship designs.

The major functions this Division is responsible for include:

- Reviewing Sealift program requirements and preparing feasibility studies
- Reviewing MSC operations to determine areas of potential improvement and economy through introduction of more efficient methods or new, more productive equipment
- Reviewing new construction plans and specifications proposed by:
  - Private operators for construction subsidies for ships which may be offered for charter to MSC
  - Naval activities for MSC nucleus and special project ships
  - Maritime Administration for national defense purposes
- Preparing contract specifications and supervising contracts for naval architectural firms to supplement MSC resources making engineering studies and developing ship concept designs into contract guidance plans and specifications for bid purposes

- Advising with respect to characteristics and costs of new construction and with respect to operating economies

(2) The Engineering Staff Prepares Estimates On An Intermittent Basis

This Division is composed of five engineers (naval architects and marine engineers) whose primary responsibilities are technical. The cost estimating functions are secondary, although the staff has three or four estimating projects each year. The reason MSC does estimating for new construction is because there are two possibilities for adding to the MSC fleet -- by a privately financed "build charter" program or through SCN budget. In the conceptual stage, they do not know how the financing will go, so they do make preliminary estimates as part of the feasibility study stage to get an idea of how much a project might cost. This is more useful if financing will be by "build charter" than if in the SCN budget. If the ship is to be included in the SCN budget, the independent estimate made by SEA 01G is used.

(3) MSC Prepares Estimates Quite Independently From NAVSEA Or Other Ship Cost Estimating Organizations Within The Navy

Unlike NAVSEC, OP96D and CNA, the MSC does its estimating quite independently from SEA 01G. MSC usually estimates from a conceptual design that will include an outline specification, basic characteristics, general arrangements and a preliminary weight estimate. With

this data, informal contracts are made to shipyards building this type of vessel for their opinion on cost as a whole or for a major weight grouping such as steel, outfit and machinery. They also have good contacts with equipment suppliers and solicit their help. They also keep track of published cost data and maintain a good informal line of communication open with estimators in MarAd.

MSC does not have a good data bank of bid data or return costs. The data bank consists of records of their past efforts and good informal lines of communications with shipyards, equipment suppliers, and other government agencies.

MSC doesn't have computer models. They use simple, direct, practial engineering costing procedures, and obtain cost information from whatever source is available.

6. THE SYSTEMS ANALYSIS DIVISION, OP96D, IS THE FINAL COST ESTIMATE VALIDATING ORGANIZATION IN THE NAVY

OP96D is a division within the Office of Chief of Naval Operations, whose major function arises from OPNAVINST 7000.17A, as follows:

> "The Systems Analysis Division (OP96) shall maintain periodic on-request studies of Navy programs. Both on-going or proposed, for the purpose of validating acquisition and ownership costs of major weapon systems, and providing the cost validation function in support of cost and effectiveness studies, CEB and NADEC presentations. This group shall have access to all data within the Navy and shall employ parametric cost analysis together with other techniques, keeping the CNM and program sponsor informed of the results of independent analyses and validation."

In this capacity, most of its estimates are prepared to independently validate or modify estimates made by all procurement commands in support of weapon systems (including ships) in connection with the DNSARC/DSARC process.

(1) <u>The Systems Analysis Division, OP96D, Is Under The Direction Of The Director Of Naval Planning, OP090</u>

Figure D.27 shows the realtive position of OP96D in the organization hierarchy of the Navy.

(2) <u>The OP96D Staff Is Small, Professional And Use Parametric Estimating Techniques</u>

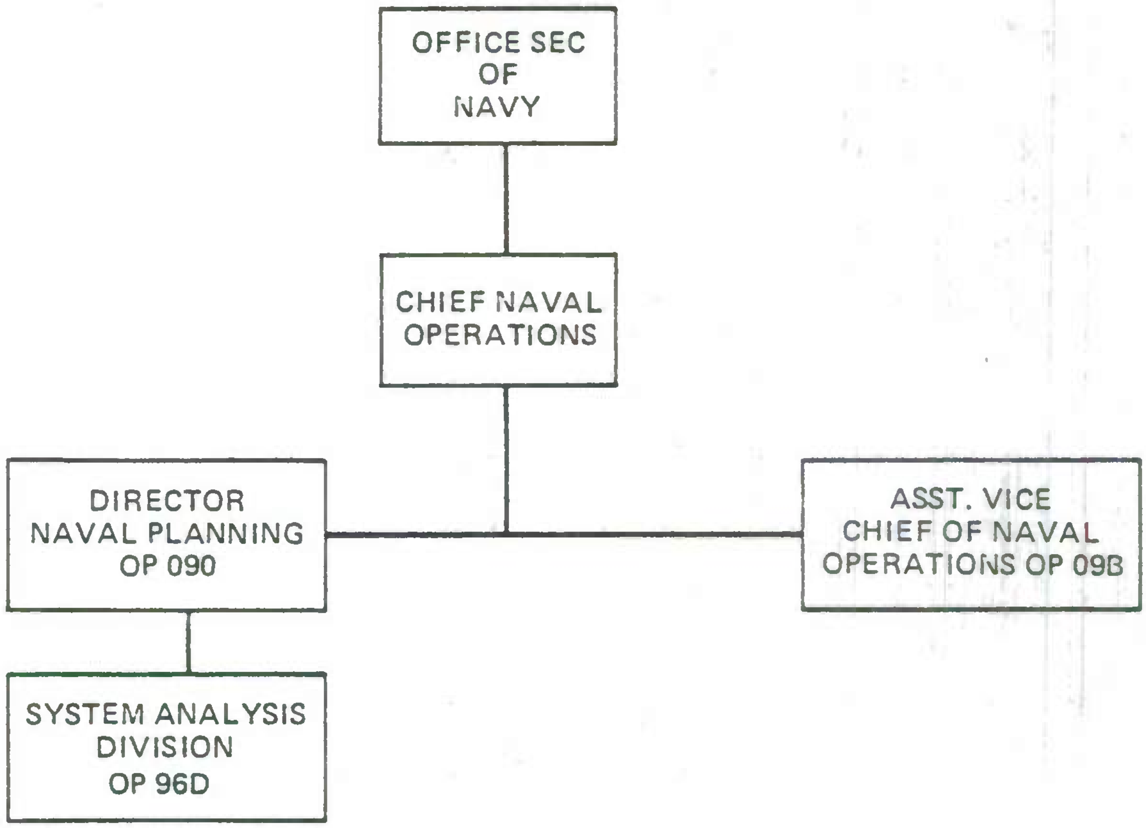
The resource of this office includes a staff of professionals. The organization is directed by a GS 16 and consists of four organizational units of two men each for Aircraft, Missiles, Electronics and Ships.

The credentials of the staff are impressive. The officers are full Commanders and the average civilian grade is GS 14. All have a basic engineering or scientific background. All have two Masters Degrees in such disciplines as econometrics, finance, statistics, etc. Three of the staff have Ph.D. Degrees.

In the case of ships, the technical and financial data used in preparing estimates comes, for the most part, from PMS and SEA 01G with support from four outside contractors. The staff also uses, as ap-

FIGURE D.27

OP 96 D IN THE CNO ORGANIZATION



propriate, a Rand ship cost model. These appear to be the basic sources of data. However, the organizational position of this staff and supporting directives gives them ready access to any information residing in the Navy.

This office uses a number of estimating techniques such as statistical comparison, regression analysis and parametric. When using parametric techniques they are, if possible, applied to the basic nine group ship construction cost and weight breakdown. The estimating procedure is very similar to that employed by SEA 01G in that they also use bid data, rather than return costs, as the basic data bank. The Rand model used is also understood to be dependent upon bid data rather than return costs. For weapon test and integration, they use a cost which is a percent of the estimated weapon cost.

(3) <u>The Independent Estimates Rely, To A Significant Degree, Upon Data Provided By SEA 01G and Project Managers</u>

OP96D advised that they use data similar to that used by SEA 01G, i.e., summary bid data, and they use weapon system costs which are aggregated in SEA 01G from the PARMs. OP96D has a very good working relationship with SEA 01G which provides OP96D with information copies of their cost analysis guidance and any other information specifically asked for. This group accepts the construction periods

established by the PMS and used by SEA 01G for the time period of the estimate. They do not make an independent evaluation of this most important cost input.

With these tools, plus their own judgement regarding market conditions, cost trends, and economic variables, OP96D develops an independent estimate. If the estimate is within eight percent of those being evaluated from the PMS, which were for the most part developed by SEA 01G, it is considered a good check.

(4) <u>OP96D Believes Cost Growth To Be Caused By A Variety Of Factors</u>

The interview with OP96D brought forth several pertinent considerations regarding control of cost growth.

- OP96D attempts to spot unrealistic estimates in the DSARC process which, in the case of low Project Managers (PMs) estimates, could avoid the appearance of cost growth had the low estimate been established as a baseline cost. As a rule, PMs estimates tend to be low to help sell the program.

- Program instability is often considered to be responsible for cost growth by reducing numbers and pushing programs further into the future. Both of these actions will cause cost growth without a technical change. It was pointed out that most of these actions were directed by the Secretary of Defense, the Chief Executive or the Congress.

- The point of view was expressed that overruns or cost growth could have a positive effect. It was theorized that if the cost estimates were not tight, all the margins would eventually get eaten up one way or another. The net effect would be to have total program cost in excess of one with a low budget and high overrun.

- OP96D, at one time, used a 95 percent learning curve. Now they are seeing no evidence of learning.

- With respect to budgeting, the OP96D personnel indicated that ideally ship estimates should be expressed in ranges, rather than as finite amounts. Some personnel in the Congressional Budget Office and in DOD understood this. However, practically, it is necessary to have a finite estimate, even if it only covers a planning wedge. Otherwise, the best that could be expected would be to cut to the lower limit of the range.

(5) <u>OP96D Believes Weapon Estimating To Be The Weakest Area In NAVSEA</u>

The OP96D interview surfaced several observations regarding SEA 01G. First, they are considered to be understaffed for their very heavy workload. They consider the estimating capability for weapons to be the area in SEA 01G where they could use help the most, as they have no capability to make independent estimates. It was also expressed that it was preferable to have a central ship estimating staff rather than providing that capability to each PMS.

(6) Conclusions

- OP96D estimating capability is geared to review and "idea" type estimating.

- For a large part, the input to SEA 01G and OP96D are almost the same.

- OP96D does not make independent analysis of program building period or impact on shipbuilding industry.

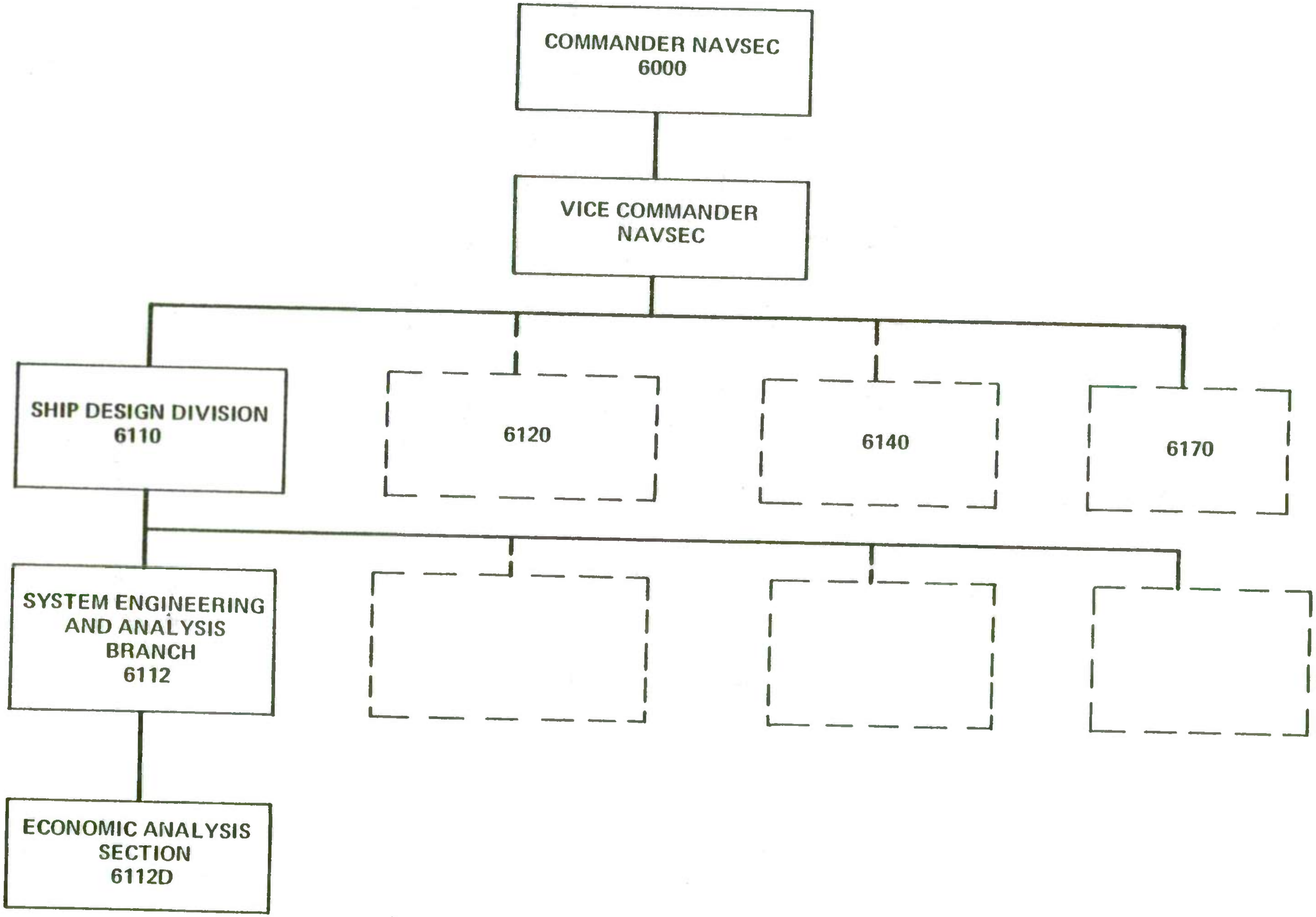
- The high percentage of rotating officers in the staff would tend to give the group a shorter corporate memory and continuity of approach than a group primarily staffed by career analysts.

7. THE NAVAL SHIP ENGINEERING CENTER (NAVSEC) HAS A COMPUTER ORIENTED SHIP CONSTRUCTION COST ESTIMATING CAPABILITY

The cost estimating and analysis function in NAVSEC resides in Code 6112D, Economic Analysis Section. The group is responsible for developing conceptual ship cost estimates for internal use of NAVSEC to maintain cost control of the development of ship design, such as "design to cost" programs, and to provide the SHAPM with approximate ship cost impact on various design features and equipment (weapons, electronics, HM&E, etc.) alternatives. Very often, the cost impact of these design alternatives are used in LCC analysis to help determine the final design selection.

The following chart shows the position of this group relative to the Commander, NAVSEC (See Figure D.28).

FIGURE D.28
SEC 6112 IN THE NAVSEC ORGANIZATION



(1) The Estimating Function Is Geared To Seven Single Digit Weight Group Parametric Estimating

The estimate for the base ship is done on the computer using the seven single digit weight groups. The data base is developed around bid data for selected shipyards that have specialized in certain ship types, i.e., DD at Bath, CVN at Newport News, etc. If the estimates are destined to be used outside the NAVSEC Command, the computer program cost inputs are first validated by SEA 01G. The features of particular interest to SEA 01G would be labor rates, overhead rate, inflation, and profit. When estimating the impact of alternate equipments or features, the three digit weight breakdown and unit equipment costs are used.

The NAVSEC estimates are not in any way associated or used in the SCN budget process and they are not subject to a formal review process. The computer model is validated by SEA 01G, but not the computer output. Within NAVSEC, there is no review by higher authority.

(2) The Estimating Staff Is Operations Research Oriented

The Economic Analysis Branch is staffed with five professionals:

	Grade	Est. Yrs. Exp.
Section Head	GS 14	8
Engineer	GS 14	12
Engineer	GS 12	3
Mathematician	GS 12	3
Mathematician	GS 9	1

The two mathematicians maintain the data base in computerized format, using information made available to them from SEA 01G and NAVSEC. The engineers perform the estimating function. The estimators use weight and design data prepared by NAVSEC, POM, guidance from SEA 01G, and GFM costs also available from SEA 01G. The estimators also obtain cost information on equipments from engineers in NAVSEC, SHAPMs, PARMs and various equipment PMs.

(3) NAVSEC Is Of The Opinion That Lack Of Firm Technical Information And Uncertainty Of The Detailed Specifications Are Major Causes Of Poor Estimates

There is a need to expand and improve the data base. Some discussions took place on the value of returned costs. It was brought out that returned cost would be very old and out-of-date when they became available. Returned costs often reflect unusual construction and claim problems that should not be factored into future considerations.

NAVSEC believes one of their most effective means for keeping program costs under control is to be able to determine cost changes identified with design development. The opinion was expressed that one major factor that drives the cost of GFM/GFI are more stringent requirements such as reliability, noise, etc. Most of these added costs eventually are reflected in the bid data used in the data base.

(4) Estimates Prepared By NAVSEC Are Commissioned By The SHAPM

NAVSEC does not do any estimating unless it can be charged to a work task assignment (WTA), subject to approval by a SHAPM. An example estimate of a CV ship acquisition cost model was made available for review. This estimate is an excellent example of computer aided parametric estimating and should serve as a model for an expanded effort in this direction.

8. THE ARMY GIVES HIGH PRIORITY TO COST ANALYSIS AND LIFE CYCLE COSTING

The Army like the Navy has a multi billion dollar budget for material procurement. In FY 1977 it was over 3 billion dollars. The FY 1977 budget authority for weapons, and track combat vehicles was $1,147,900;000, of this amount $982,666,000 was for tracked combat vehicles alone.

In the past the Army has also had its problems with overruns and cost growth. In order to improve its credibility with OSD and Congress, the Army, in 1973, established a Cost Analysis Directorate in the Office of the Chief of Staff with a total staff throughout the Army of over 400 cost analysis and cost estimating professionals. Of this total, 260 professionals have been assigned to the Development and Readiness Command (DARCOM) which is responsible for design and procurement of Army material.

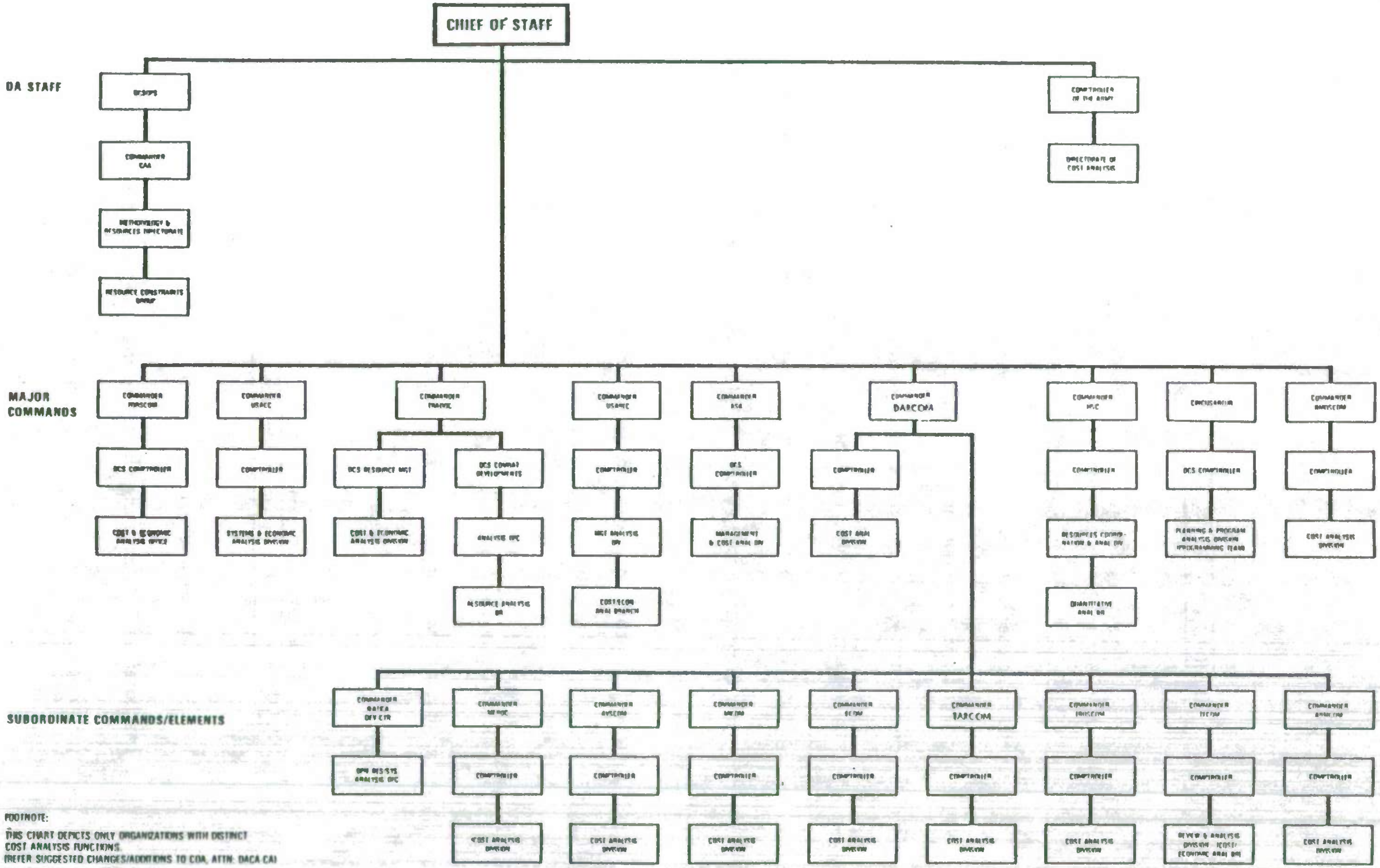
The Cost Analysis Program embraces the entire spectrum of considerations and resources needed to define Life Cycle Cost of a material system, i.e., tanks, aircraft, etc. Exhibit D.7 (developed by the Army) identifies program objectives as related to the wide range of responsibilities assigned to the staff to carry out program policy.

(1) The Cost Analysis Function Is Performed In Each Layer Of Command

The Directorate of Cost Analysis in the Office of the Chief of Staff has a total of 36 professionals, including six offices. The successive command layers also have Cost Analysis Divisions, as shown on Figure D.29. In DARCOM, there is a Cost Analysis Division in the Office of the Commander and one for each of eight procurement Commands. These offices range in size from 10-15 professionals.

FIGURE D. 29

THE ARMY COST ANALYSIS COMMUNITY



FOOTNOTE:

THIS CHART DEPICTS ONLY ORGANIZATIONS WITH DISTINCT COST ANALYSIS FUNCTIONS.
(REFER SUGGESTED CHANGES/ADDITIONS TO COA, ATTN: DACA CA)

* GENERAL STAFF AND TECHNICAL GUIDANCE FOR THE COST ANALYSIS FUNCTION FLOWS THROUGH COMPTROLLER CHANNELS.

(2) The Cost Analysts Function Is To Provide To Management Realistic Cost Estimates

According to the Army, a cost analyst is an individual qualified through formal training and work experiences to provide to management the most credible and realistic cost estimates. A cost analyst is broad-gauged and management oriented. They are multi-disciplined professionals who employ operations research, engineering and econometric techniques to prepare, evaluate and validate cost estimates. Their primary interest is assuring that the overall cost to the Government of material systems, forces, units and activities is presented in ways which yield cost realism. A cost analyst's product is technical papers and reports containing findings and, where appropriate, recommendations.

A cost analyst is not a price analyst or a budget analyst. He is not a requirements planner. While a cost analyst is not a contract price analyst, budget analyst or requirements planner, he should have an understanding of these functions to fulfill his role.

(3) The Cost Analysis Program Is Designed To Validate The Reasonableness Of Program Managers Estimates

There are two estimates made for each major material acquisition, the Baseline Cost Estimate (BCE) and the Independent Parametric Cost Estimate (IPCE).

. The Baseline Cost Estimate is a term denoting a complete, detailed and fully documented estimate of material system life cycle costs accomplished by the system proponent (weapon system project manager). It is a dynamic document, appropriately refined and updated throughout the acquisition cycle. It serves, after review and validation, as the principal cost estimate for that system. If appropriate, the Comptroller of the Army will propose to ASARC principals a preferred Army program estimate through the mechanisms of the Army Cost Analysis Paper (ACAP) or Cost Analysis Brief (CAB). In this event, the BCE may require modification to reflect the will of ASARC principals prior to being recording in management decision recording documents such as the Decision Coordinating Paper (DCP). A BCE completed for ASARC/DSARC I (the decision to allow a project to proceed from its conceptual phase into validation), is known as the Planning Estimate. The BCE completed for ASARC/DSARC II (decision allowing a project to proceed into full scale development), is known as the Development Estimate.

- The BCE (including subsequent updates) is used as --

  a) The principal institutional source document for cost information related to the materiel system including design-to-cost goals.

  b) The basis for projecting funding requirements for acquisition and operation of the materiel system.

  c) The benchmark (initial BCE) and source (updated BCE's) for system cost tracing.

  d) The basis for cost inputs to such reports as the Selected Acquisition Report (SAR).

- The Materiel Developer is responsible for developing the initial BCE and for keeping it updated as the system progresses through its acquisition

phases. The Materiel Developer is responsible for including a Requirements Specification as part of the BCE documentation. The Requirements Specification will be completed by COA in coordination with DCSRDA, DCSOPS, and DCSLOG,* to the fullest extent possible.

- BCE's reflect a variety of costing approaches. If the initial BCE is developed prior to contractor involvement in the program, system design will not be well defined and will usually permit costing only by parametric techniques. As system definition improves and contractor participation increases, BCE's reflect increasing use of detailed engineering cost estimates. As a minimum, the BCE will be updated for each major decision point (ASARC milestones or IPR equivalents) in the acquisition cycle.

- Headquarters Department of the Army (HQDA) (COA) provides overall guidance and direction to the field commands for estimating and reporting baseline costs.

• The Independent Parametric Cost Estimate (IPCE) is a highly aggregated output (physical and/or performance parameter) related materiel system life cycle cost estimate accomplished outside of the functional control of program proponents.

  - The IPCE is developed to test the credibility of the proponent's Baseline Cost Estimate and to provide a second opinion as to the cost at key decision points in the acquisition cycle.

* COA - Comptroller of the Army
DCSRDA - Deputry Chief of Staff for Research Development and Acquisition
DCSOPS - Deputy Chief of Staff for Operations and Plans
DCSLOG - Deputy Chief of Staff for Logistics

- In addition to its principal purpose of testing the reasonableness of the BCE, the IPCE is used for exploring cost sensitivities of the assumptions used in the BCE. This includes such factors as the probable impact of technical failures, changes in configurations, schedule testing requirements, prototype quantities, inflation rates, and deployment.

- HQDA (COA) provides overall guidance and direction for developing IPCE's and performs IPCE's for selected materiel systems.

- IPCE's reflect use of one specific costing technique, that of developing cost as a function of selected system parameters, called variables. Salient characteristics of an IPCE are:

  a) It is system output related, examining cost in terms of what is being purchased and operated, such as the physical, performance or operational characteristics of the system, rather than in terms of what the funds are paying for (labor, material).

  b) Its scope encompasses the total life cycle of a system -- the resources required to develop, acquire, operate and support the system.

  c) It uses actual cost experience on similar, earlier systems (including those of other military departments and commerical accounts) to the greatest extent applicable through statistical conversion of such experience to cost estimating relationships (CERs) and cost factors. Nonparametric estimating methodology (analogy, detailed buildup, expert opinion) is used only for those cost elements for which inadequate data exists for statistical analysis.

d) It includes full documentation, so as to permit complete reproduction of the estimate and of the CER's and cost factors used. It includes a Requirements Specification, completed to the maximum extent possible, as part of the IPCE documentation.

e) It explores the cost sensitivity of critical assumptions and program uncertainties.

- Independent Estimates utilize a wide range of methodology. This can vary from an industrial engineering approach to the use of cost estimating relationships and more advanced parametric methods. Usually systems in early and mid stages of development lend themselves to parametric estimating. As knowledge and experience with the system increases, the engineering type of estimates become more feasible.

  - The purpose of an Independent Estimate is to provide an unbiased, second estimate of a system's cost which can serve as a test of reasonableness of the BCE. It provides management with an important tool for decision purposes at key decision points.

  - In the vast majority of cases, the Independent Estimate takes the form of an IPCE. The Independent Estimate is made and used by DARCOM for all systems and decision points.

(4) <u>The Approach For Making The BCE And IPCE Are Substantially Different</u>

Estimates for materiel system acquisition costs are either derived from detailed, grass-root calculations (the industrial engineering approach) or based on the relationships between more aggregate components of

system cost and the physical and/or performance characteristics of the system. These relationships should be derived from cost histories on prior programs. The latter method is often called the parametric approach. Two additional descriptors have come into common usage because of the clarity with which they capture the essential differences: Bottoms-up for the detailed industrial engineering approach and Top-down for the parametric approach.

- Historically, defense contractors have employed the bottoms-up approach in their proposal pricing and planning purpose estimates for the Government. Because of Government Project Managers (PM's) responsibilities in connection with defense contractors, it has evolved that PM estimates of program costs mirror the detailed work breakdown structure (WBS) associated with contractor cost estimates. Thus the PM estimate, described as the Baseline Cost Estimate (BCE), usually reflects bottoms-up estimating methodology.

- The advent of top-down cost estimating methods brought the opportunity for a genuine cross-check of detailed bottoms-up cost estimates. The descriptor, Independent Parametric Cost Estimate (IPCE), has been given to those estimates employing the top-down cost estimating methodology.

During the early phases of the acquisition process only limited requirements information is available. The top-down approach is particularly suited to making estimates based on limited physical and performance information. The descriptor "Cost and Operational Effectiveness Analyses" (COEA) has been given to those cost effectiveness studies

performed, principally, in the early acquisition phases. Investment phase costs of system alternatives evaluated in COEA are derived using, principally, the top-down cost estimating approach.

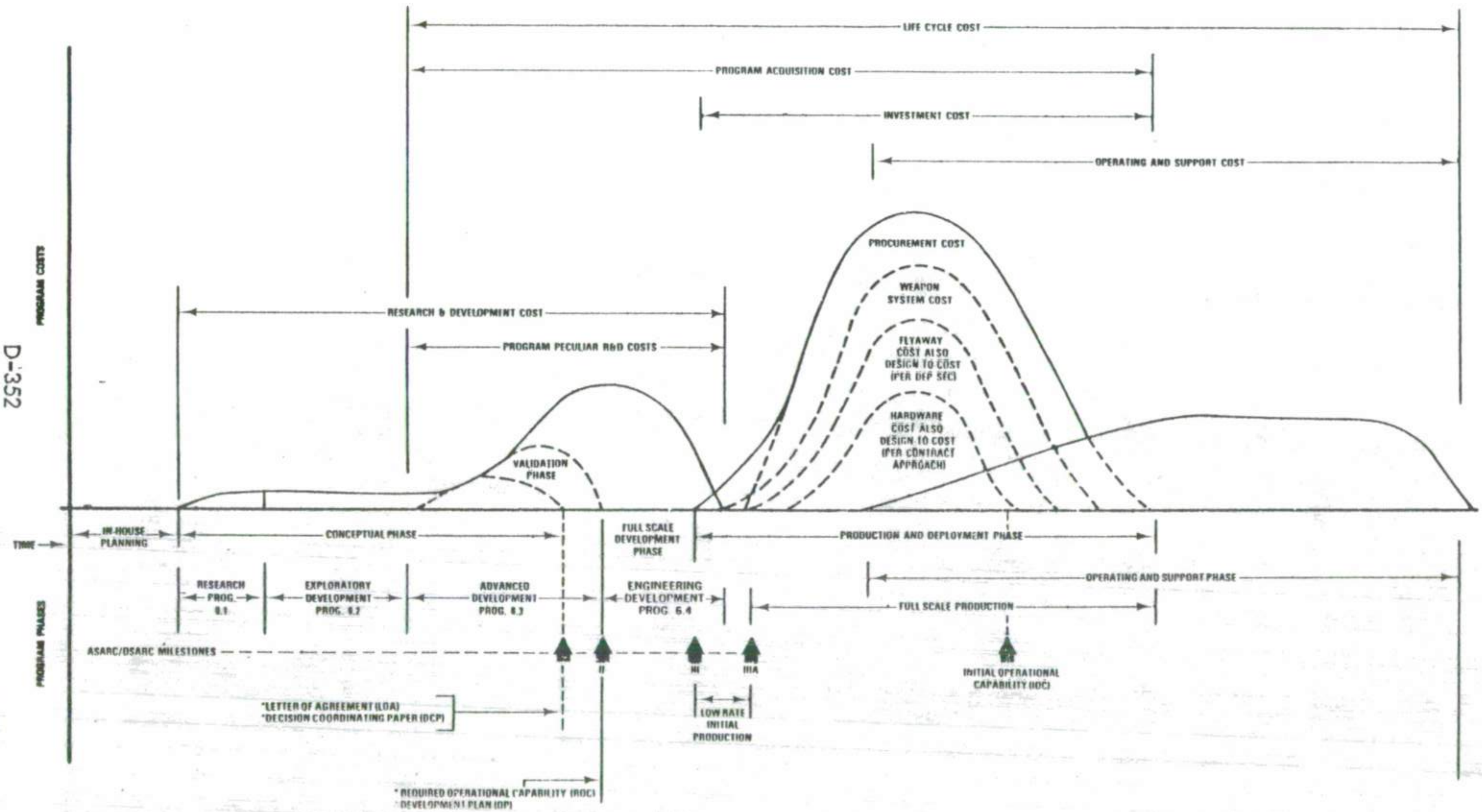
For the cross-checking or validation process to be productive, it is necessary that a common ground be created whereupon differently derived estimates may be compared, analyzed and judged. A crucial criterion in the selection of such a common ground is that the WBS selection should not preclude (by its inherent composition) the choice of either top-down or bottoms-up methods. While it is possible to aggregate detailed costs, it is not possible to disaggregate composite costs any lower than the level of cost used in creating the cost estimating relationship. Thus, the common ground, as would be reflected in a WBS, must take into consideration perceptions of the general level of detail upon which cost estimating relationships are based. This is a function of the overall quality and general structure of the historical data base and the levels of cost aggregation at which cost analysts conventionally work.

(5) <u>The Army Has Developed A Common Framework For Investment Phase Cost Estimates</u>

The Life Cycle Cost of materiel system is illustrated in Figure D.30. The pattern reflected and life cycle phases depicted are common

FIGURE D-30

LIFE CYCLE OF A MATERIEL SYSTEM



to materiel systems. An understanding of the meaning of "materiel system" and a categorization of Life Cycle Costs into Research and Development, Investment, and Operating and Support phases has evolved. A convention for approaching the sub-sets of each life cycle phase has also evolved. This general framework is designed for use by both managers and analysts at all levels where cost analysis is performed.

- The Army Life Cycle Cost Matrix for general cost communication for all program estimates prepared by the Army is presented in Figure D.31. This common framework has evolved under the following criteria:

  - It must be compatible with both top-down and bottoms-up cost estimating approaches. The framework must not, by its composition, preclude use of either approach. It must be compatible with cost analysis policy and convention.

  - It must capture 100 percent of costs. It must be comprehensive, but not necessarily detailed.

  - It must be manageable in size. Simplification in level of cost analysis detail is essential.

- The investment cost elements are listed in Table D.16 with element numbers to indicate first and second level of indenture elements. The second level elements sum to the first level investment cost. Figure D.32, Investment Cost Element Structure, shows the relationship of the investment elements by a line and block diagram. These cost elements and definitions are common to all materiel system investment phase cost estimates (e.g., BCE's, IPCE's, and cost estimates contained in COEA's).

(6) The Same Life Cycle Cost Matrix Is Used For Major Materiel Systems

Figure D.33 shows how the Life Cycle Cost Matrix categories relate to the column headings for Aircraft Systems, Missile Systems, Surface Vehicle Systems, Electronic Systems and Ordnance Systems. Exhibit D.6 provides the generic definitions for the systems structure categories listed in Figure D.31.

(7) The XM1 Battle Tank Is A Good Example Of How The Army Is Currently Attempting To Keep Costs Within Pre-Determined Limits

The process by which the XM1 battle tank is being handled will illustrate the Army's current procurement procedure. The XM1 project is an outgrowth of an unsuccessful joint United States and West German effort to develop a new main battle tank, the MBT-70, for the 1970's. The joint effort began in 1963 and was terminated in 1970 due to the inability to agree on key component parts. In 1971, the U.S. Army follow-on program, the XM-803, was terminated by Congress due to excessive hardware costs of over $600,000 per tank. The Army, in an attempt to modernize its tanks, formed another main battle tank task force in 1971 designated as the XM1 Tank System.

Figure D.34 is a time/phase diagram of the XM1 program. The program has passed DSARC II and Chrysler has been selected as the

FIGURE D. 31
ARMY LIFE CYCLE COST MATRIX

ROW	PRIME APPRO	DEFN REF	SYSTEM STRUCTURE* / COST ELEMENT	(1) FRAME	(2) PROPULSION	(3) GUIDANCE CONTROL/ COMMUNICATIONS	(4) FIRE CONTROL	(5) ARMAMENT	(6) PAYLOAD/ AMMUNITION	(7)** (TO BE SPECIFIED)	(8) PECULIAR SUPPORT EQUIPMENT	(9) COMMON SUPPORT EQUIPMENT	(10) OTHER	(11) TOTAL	(12) PERCENT
1		1.0	RESEARCH AND DEVELOPMENT												
2	RDTE	1.01	DEVELOPMENT ENGINEERING												
3	RDTE	1.02	PRODUCIBILITY ENGINEERING AND PLANNING (PEP												
4	RDTE	1.03	TOOLING												
5	RDTE	1.04	PROTOTYPE MANUFACTURING												
6	RDTE	1.05	DATA												
7	RDTE	1.06	SYSTEM TEST AND EVALUATION												
8	RD/OM	1.07	SYSTEM/PROJECT MANAGEMENT												
9	RD/OM	1.08	TRAINING												
10	RD/MC	1.09	FACILITIES												
11	RDTE	1.10	OTHER												
12		2.0	INVESTMENT												
13	PR/MC	2.01	NON RECURRING INVESTMENT												
14	PROC	2.02	PRODUCTION												
15	PROC	2.03	ENGINEERING CHANGES												
16	PR/OM	2.04	SYSTEM TEST AND EVALUATION												
17	PR/OM	2.05	DATA												
18	PR/OM	2.06	SYSTEM/PROJECT MANAGEMENT												
19	PR/MC	2.07	OPERATIONAL/SITE ACTIVATION												
20	PR/OM	2.08	TRAINING												
21	PR/OM	2.09	INITIAL SPARES AND REPAIR PARTS												
22	PR/OM	2.10	TRANSPORTATION												
23	PR/OM	2.11	OTHER												
24		3.0	OPERATING AND SUPPORT COST												
25		3.01	MILITARY PERSONNEL												
26	MPA	3.011	CREW PAY AND ALLOWANCES												
27	MPA	3.012	MAINTENANCE PAY AND ALLOWANCES												
28	MPA	3.013	INDIRECT PAY AND ALLOWANCES												
29	MPA	3.014	PERMANENT CHANGE OF STATION												
30		3.02	CONSUMPTION												
31	PR/OM	3.021	REPLENISHMENT SPARES												
32	OMA	3.022	PETROLEUM, OIL AND LUBRICANTS												
33	PROC	3.023	UNIT TRAINING, AMMUNITION AND MISSILES												
34		3.03	DEPOT MAINTENANCE												
35	OMA	3.031	LABOR												
36	PR/OM	3.032	MATERIEL												
37	OMA	3.033	TRANSPORTATION												
38	PROC	3.04	MODIFICATIONS, MATERIEL												
39		3.05	OTHER DIRECT SUPPORT OPERATIONS												
40	OMA	3.051	MAINTENANCE, CIVILIAN LABOR												
41	OMA	3.052	OTHER DIRECT												
42		3.06	INDIRECT SUPPORT OPERATIONS												
43	MP/OM	3.061	PERSONNEL REPLACEMENT												
44	MPA	3.062	TRANSIENTS, PATIENTS AND PRISONERS												
45	OMA	3.063	QUARTERS, MAINTENANCE AND UTILITIES												
46	MP/OM	3.064	MEDICAL SUPPORT												
47	OMA	3.065	OTHER INDIRECT												
48			TOTAL SYSTEM COST (LESS EROA)												
49	EROA	4.0	EROA COST												
50			TOTAL SYSTEM COST (WITH EROA)												

100%

*THE COLUMN HEADINGS SHOWN ARE GENERIC, USED FOR DISCUSSION OF SYSTEMS IN GENERAL. FOR SPECIFIC STUDY, SPECIFIC COLUMN HEADINGS ARE [illegible] PROVIDED IN APPENDIX A.

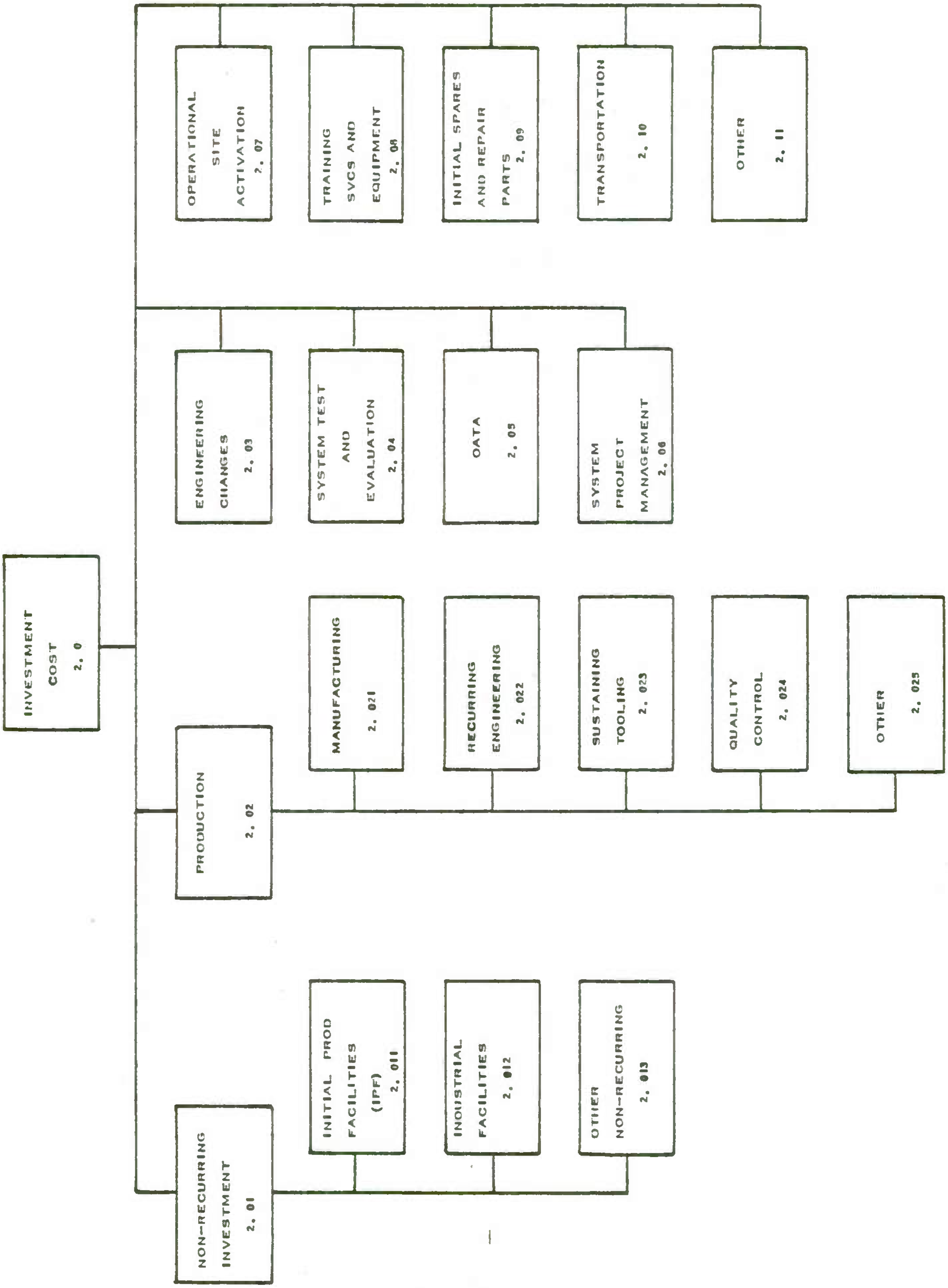
**USED FOR A SPECIFIC HARDWARE COMPONENT/SUBSYSTEM OF HIGH MANAGEMENT INTEREST, NOT CAPTURED ELSEWHERE.

TABLE D.16

INVESTMENT COST ELEMENTS

Element Number	Cost Element
2.0	Investment Cost
2.01	Non-Recurring Investment
2.011	Initial Production Facilities (IPF)
2.012	Industrial Facilities/Production Base Support
2.013	Other Non-Recurring
2.02	Production
2.021	Manufacturing
2.022	Recurring Engineering
2.023	Sustaining Tooling
2.024	Quality Control
2.025	Other
2.03	Engineering Changes
2.04	System Test and Evaluation
2.05	Data
2.06	System/Project Management
2.07	Operational/Site Activation
2.08	Training Services and Equipment
2.09	Initial Spares and Repir Parts
2.10	Transportation
2.11	Other

FIGURE D.32



Investment Cost Element Structure.

FIGURE D.33

CORRELATION BETWEEN SYSTEM STRUCTURE CATEGORIES (COLUMNS) IN COST MATRIX AND MIL STD 881

SPECIFIC / GENERIC	AIRCRAFT SYSTEMS		MISSILE SYSTEMS		SURFACE VEHICLE SYSTEM		ELECTRONIC SYSTEM		ORDNANCE SYSTEM	
	LIFE CYCLE COST MATRIX	MIL STD 881	LIFE CYCLE COST MATRIX	MIL STD 881	LIFE CYCLE COST MATRIX	MIL STD 881	LIFE CYCLE COST MATRIX	MIL STD 881	LIFE CYCLE COST MATRIX	MIL STD 881
1. Frame	Airframe	Airframe	Airframe	Missile Integration & Assembly	Hull, Turret & Suspension	Body/Cab Hull/Frame Turret Assembly Suspension/ Steering Integration & Assembly	Automatic Data Processing Subsystem	ADP Equip	Cartridge	Cartridge Launch System Integration & Assembly
2. Propulsion	Power Plant	Power Plant	Propulsion	Propulsion	Power Package	Power Package/ Drive Train	Data Display Subsystem	Data Displays		
3. Guidance and Control Comms Equip	Communications, Navigational/ Guidance	Communications, Navigation/ Guidance Auto/Flight Control Penetration Aids Recon Equip	Missile Guidance & Control	Missile Guidance & Control Equip	Communications Equipment	Communications & Navigation Equipment	Communications Subsystem	Communications	Communications Equipment	
4. Fire Control	Fire Control	Fire Control	Fire Control & Other Comms Equipment	Surveillance, Ident & Tracking Sensors Launch & Guidance Control Communications Data Processing	Fire Control	Fire Control	Sensor Subsystem	Sensors	Fire Control	Fire Control Equipment
5. Armament	Armament	Armament Weapons Delivery Equipment Aux Arm/Wpn Del Equipment	Launcher	Launcher Equip Command & Launch Equipment Integration & Assembly	Armament	Armament	Aux Equip Subsystem	Aux Equip	Launcher	Launcher
6. Payload/Ammo	Ammunition		Missile Payload	Launched Payload Payload Shroud	Ammunition				Complete Round	Complete Round (WBS Level III)
7. To Be Specified	Specified		Specified		Specified		Specified		Specified	
8. Peculiar Spt Equip	Peculiar Spt Equip	Peculiar Spt Equip	Peculiar Spt Equip	Peculiar Spt Equip	Peculiar Spt Equip	Peculiar Spt Equip	Peculiar Spt Equip	Peculiar Spt Equip	Peculiar Spt Equip	Peculiar Spt Equip
9. Common Spt Equip	Common Spt Equip	Common Spt Equip	Common Spt Equip	Common Spt Equip	Common Spt Equip	Common Spt Equip	Common Spt Equip	Common Spt Equip	Common Spt Equip	Common Spt Equip
10. Other	Other	As Required For [illegible] Coverage	Other	As Required For [illegible] Coverage	Other	As Required For [illegible] Coverage	Other	As Required For [illegible] Coverage	Other	As Required For [illegible] Coverage

manufacturer to build 14 prototypes. After DSARC III, scheduled for early 1979, the current plan is to award Chrysler the first production contract for 110 tanks in mid 1979.

The XM1 Tank System was mandated as "Design-to-Cost" in 1972 and controls were written into the contract so that the Project Manager (PM) could monitor return cost data so as not to exceed cost goals. The PM is assisted by a staff professional engineers who track the schedules and have cognizance of the integration of the various assemblies for the XM1. The life of a tank is approximately 20 years and it will take about 10 years to build all the programmed XM1 Tank Systems. The XM1 Tank System Project Office has as its PM a Major General and is physically located in Warren, Michigan close by the Chrysler plant, the manufacturer of the XM1.

Figure D.35 shows the organizational position of XM1 Project Office in relation to the Army Chief of Staff and the Material Development and Readiness Command (DARCOM). Because of the magnitude of this project, it is directly under the Commander, DARCOM. Other projects such as Mechanized Infantry Combat Vehicle (MICV) and the M-60 Tank come under the Tank Automotive Material Readiness Command (TARCOM).

FIGURE D.34

XMI TANK PROGRAM BACKGROUND

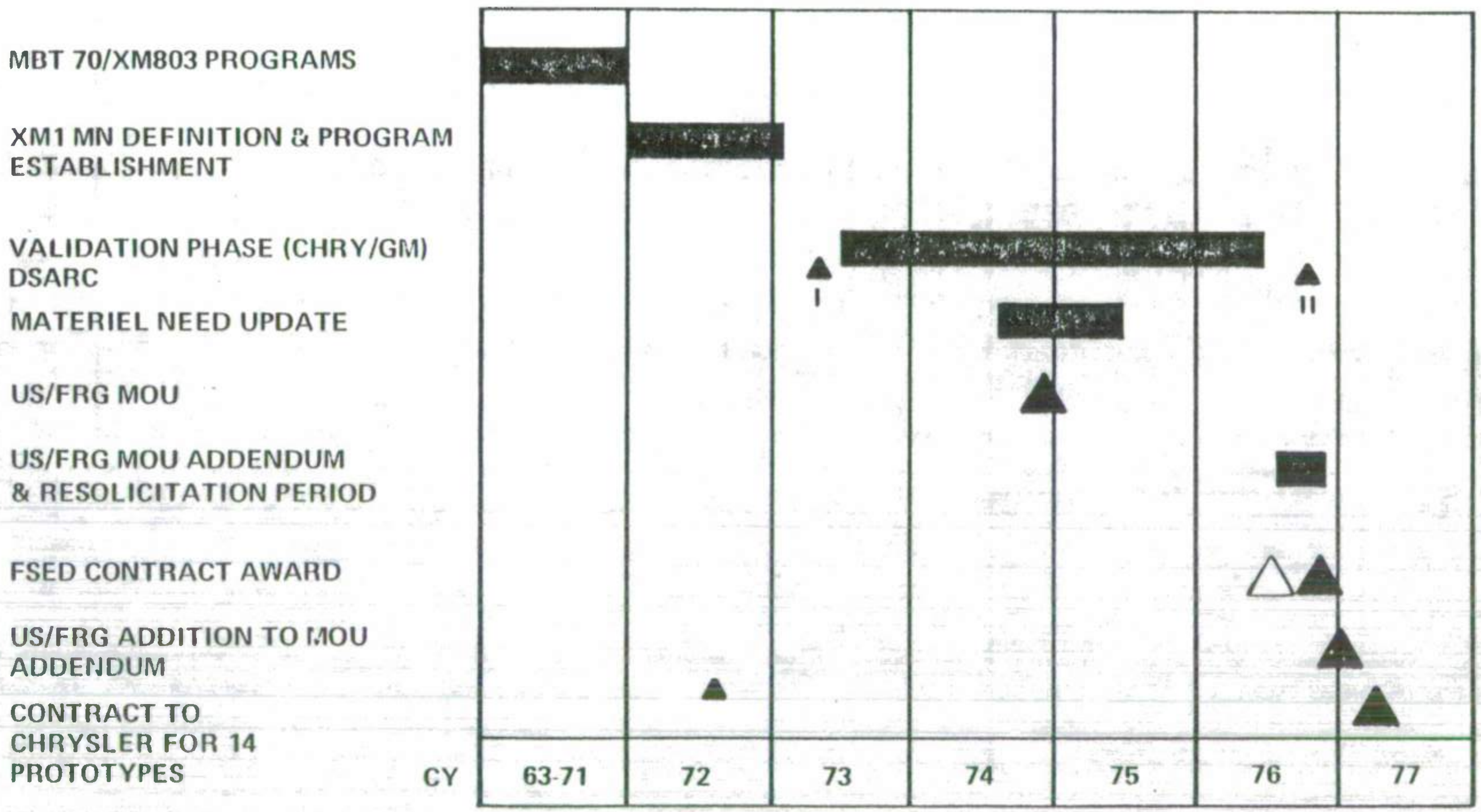
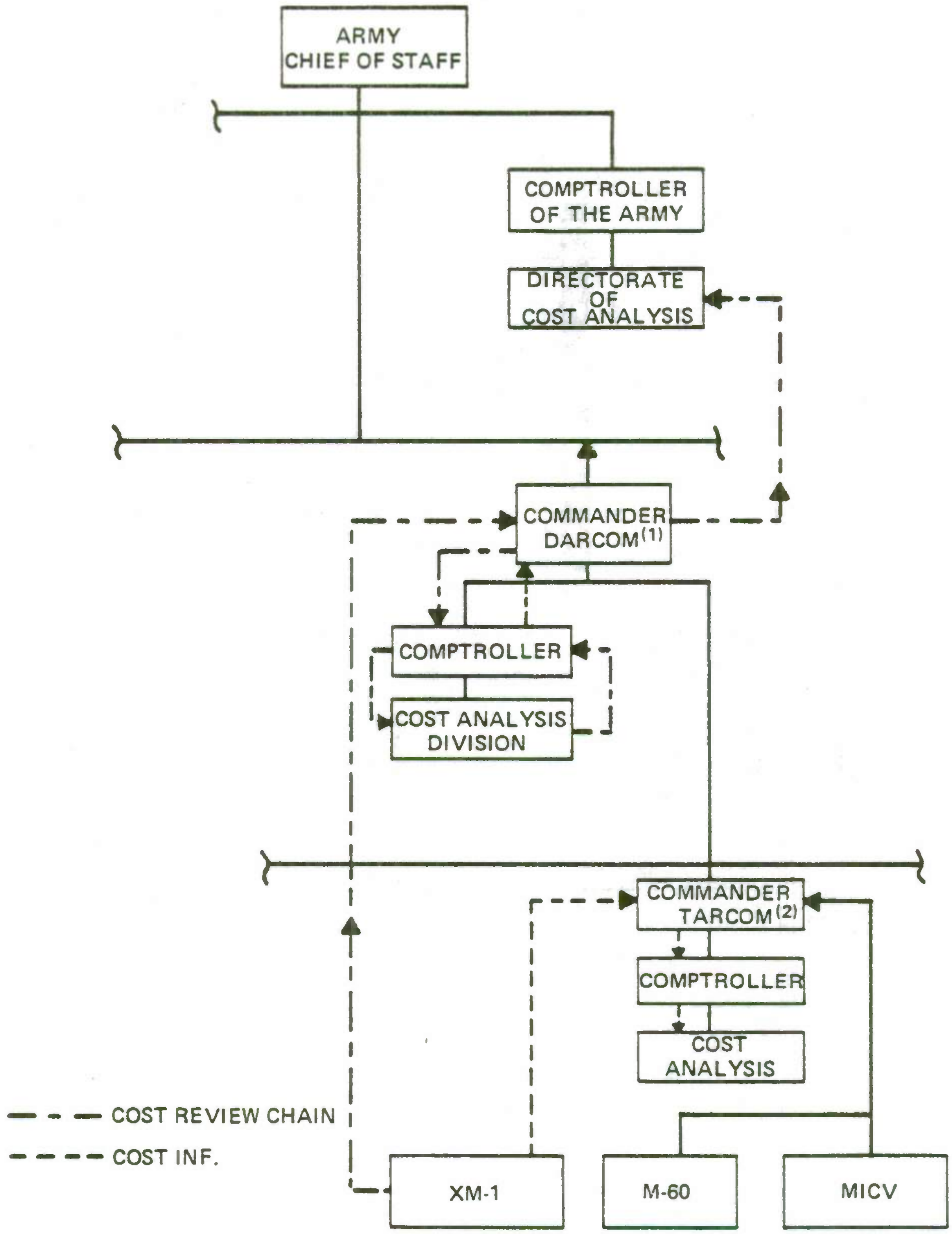


FIGURE D-35

XM-1 PROJECT OFFICE IN THE MATERIAL DEVELOPMENT AND READINESS COMMAND (DARCOM)



(1)DEVELOPMENT AND READINESS COMMAND

(2)TANK AUTOMOTIVE MATERIAL READINESS COMMAND (TARCOM)

Upon the establishment of the project, a task force was organized composed of staff from the Project Manager's office, the Army Cost Analysis Directorate, and the Army Development and Readiness Command to prepare a cost study of the new tank. In 1972, the PM issued a study which provided a parametric cost of what the tank should cost, based on a Research and Development (R&D) program. This program was developed by making a unit cost analysis of existing hardware components that could be used, so the program could go into production within six years. Included in the cost analysis was the impact of a gas turbine versus diesel engine, different suspension tracks, and different guns. The study took approximately six months to complete, which represented three man-years of effort.

The task force received much outside help from the Cost Information and Analysis Branch within the Project Manager's Office. Chrysler and General Motors (GM) also had inputs into the task force study. The Design-to-Cost goal of the task force for the program was $507,000 (in 1972 dollars) for each tank with a total of 3,312 tanks. This program cost was accepted by Congress.

General Motors and Chrysler were given contracts to develop two competitive prototype versions of the XM1 Tank. During the advance development phase the Army validated, both GM and Chrysler at three

different times to determine that their costs were below the $507,000 DTC thresholds by reviewing detailed unit hardware cost submissions from the contractor based on a standard Work Breakdown Structure (WBS) for the Main Battle Tank, XM1. These validated costs were given a detailed study by the Project Manager, corrections made, and then became the Army Baseline Cost Estimate (BCE).

The Chrysler version was finally chosen, but certain aspects of the design are still not firm. For example, whether the gun will be 105 mm or 120 mm will not be decided until December 1977. However, the design is sufficiently flexible to permit either gun and the subsequent projectile stowage differences. Both GM and Chrysler had the leeway to change the design within certain ranges for sixteen categories of performance, such as fire power and protection, but changes could not cause deviation from three fixed criteria such as RAM-D,* weight, or exceed the cost threshold of $507,000 (in 1972 dollars). It was emphatically stated that the competitive process between the two companies has kept the price down and produced a better tank.

In November 1976, the XM-1 completed the Defense Systems Acquisition Review Council (DSARC II) phase. The contractor de-escalates his current year hardware estimate to 72 dollars to compare to the $507,000 threshold by the following agreed upon indexes.

* Army's Reliability, Availability, Maintainability and Durability Program.

Index A - BLS-WPI code 101, Iron and Steel

Index B - UAW Labor Rates

Index C - WPI Manufacturer Durable Goods

The XM-1 Project Management Division has compared Chrysler's inflation factors with those issued by DARCOM (based on DOD factors) and thus far these factors have tracked very closely. Cost analyses of the Chrysler/GM cost estimates and the Budget estimates for the XM-1 were developed by the Project Management (PM) Division and the budget number was based on the estimate made by the PM, not Chrysler. For the original program procuring 3,312 units at an average estimated cost of $507,000 per unit the Chrysler and GM costs were always below the ceiling estimate so the budget cost was the Chrysler estimate adjusted by the XM-1 PM.

- In FY 76 dollars:
  - Chrysler estimate $621,000
  - XM-1 PM estimate $681,000
  - Ceiling remains $755,000 (equal to $507,000 in 72 dollars)

The PM estimators keep close contact with the Chrysler costs as they occur for the XM-1. A "Cost Performance Report (CPR)" for the R&D phase and a "Budgetary Cost Estimate for Production Program"

are provided monthly by Chrysler and the detailed breakdwon of the major components indicate if the cost is plus or minus, and if over states what is the cause, what is being done or will be done to reduce costs. The above cost information is part of the Cost/Schedule Control Systems Criteria (C/SCSC) which was invoked by DOD Instruction 7000.2. In addition to the cost information, the Cost Estimating and Analysis Branch has access to a time-shared standard cost model program that was developed by the Air Force which provides cost trend charts based on the CPR monthly data.

The Cost Estimating and Analysis Branch has five professional cost estimators, all college graduates with degrees as follows:

2 Mechanical Engineers
1 Business Administration Major
1 Industrial Engineer
1 Mathematician

All are classified by civil service as Operation Research Analysts. They are GS-13 with the exception of the Branch Head who is a GS-14. The five average approximately 30 years of age, with an average of 6-7 years as cost estimators and their estimating experience has been for the most part with the Government.

The BCE developed by the PM is being constantly validated and all formal reports, Selected Acquisition Reports (SARs), budget

cost estimates are formally reviewed by various Army groups such as:

- The Tank Automative Readiness Command (TARCOM) as a courtesy since the XM1 PM reports directly to the Commander, DARCOM. TARCOM is kept informed as the XM1 will come under TARCOM in 1982 when it goes into full production. (The M-60 tank, for example, is under cognizance of TARCOM.)

- The Cost Analysis Division in the Office of the Comptroller, DARCOM.

- The Systems Estimates Division located in the Directorate of Cost Analysis in the Office of the Comptroller of the Army (COA).

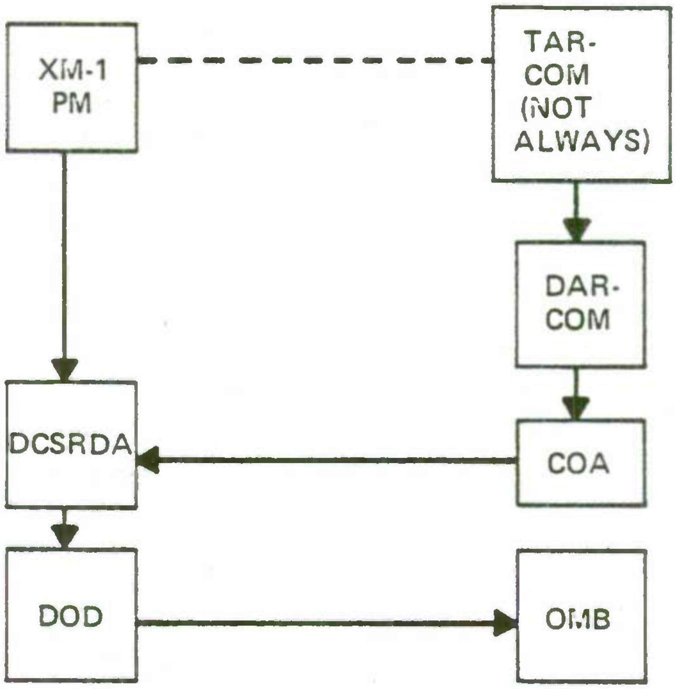
- Cost Analysis Improvement Group (CAIG) which will review prior to receipt of cost estimates by the Army Systems Acquisition Review Council (ASARC).

Budget (POM) cost estimates originate in the Office of the XM1 Project Manager. There is a Program Budget and Fiscal Branch. This group does put the budget requirements together, but the Cost Information and Analysis Branch is responsible for the cost estimates that go into the budget. The following Figure D.36 illustrates the offices involved in the review of the budget cost estimates.

The XM1 Project Manager has an organization which is unique in the Army since it provides its own Contracting Office, a Cost Information and Analysis Branch, and a Program Budget and Fiscal Branch. The functions of these three offices are performed normally by the Tank Automotive Material Readiness Command (TARCOM) on other smaller

FIGURE D.36

OFFICES INVOLVED IN REVIEW OF BUDGET COST ESTIMATES



DCSRDA - DEPUTY CHIEF OF STAFF FOR RESEARCH, DEVELOPMENT AND ACQUISITION
COA - COMPTROLLER OF THE ARMY

systems. This concentration of functions within the office of the XM1 PM has no doubt contributed to the cost thresholds being maintained. Another favorable feature is that the XM1 office is physically located in the proximity of the Chrysler XM1 plant and offices.

The PM is of the opinion that competition between GM and Chrysler has been the main reason that the $507,000 cost per tank threshold has not been exceeded and that a better tank has been developed. To maintain competition now that the contract has been awarded Chrysler for fourteen prototypes, the Army has a Design-to-Cost award fee agreement with Chrysler. The award fee of $7,200,000 is, in effect, a bonus that will be paid Chrysler in five increments if the target cost is held down to the cost threshold establsihed by the Army. The first increment of 10 percent ($720,000) scheduled for September 1977 with other increments given periodically. The last increment of $4,000,000 will be paid when a contract (fixed price incentive) for the first 110 tanks is signed. The Army will also go sole source for the second lot of 352 tanks.

They have signed ceiling options for the first and second contracts (i.e., 110 tanks and 352 tanks) and is considering negotiating a ceiling option for the third contract.

The following are distinct steps to hold down the costs for the XM1:

- Compeition during development
- Design-To-Cost Award Fee during prototype phase
- Ceiling options signed well in advance, as the initial production contract award will be approximately mid-1979

The rollaway cost (in 1972 dollars) of the XM1 tanks is $530,000, not $507,000. This is because the Government (Army) owns the buildings and all the machinery used to build the XM1's and Chrysler is , therefore, a sub-contractor who manages the program for the Army. If the tanks are built in one plant the Army would most likely go sole source procurement for all future XM1 buys, since changing contractors would delay the program approximately one year.

The Army has plans to eventually use another plant to manufacture XM1's; not a mirror image of the first, but close enough so that another company besides Chrysler could take over plant #2 if the situation warrants it.

The principal cost review office for the XM1 Project Manager is the Material Development and Readiness Command (DARCOM) Cost Analysis Division (Figure D.35). The Cost Analysis Division's function

is to:

- Compare the Independent Parametric Cost Estimate (IPCE) generated outside the DARCOM to the Project Baseline Estimate (BCE) which is generated by the DARCOM. IPCEs for the big five (one of which is Main Battle Tank XM1) are provided by the Department of the Army Cost Analysis Directorate
- Review DARCOM IPCEs and BCEs
- Direct DARCOM's IPCE effort (non big five)
- Provide inflation guidance

Basically, this Division is responsible for coordinating all cost analyses data and factors relating to weapons system costing.

This group of five people perform cost analyses for all tanks, all electronics, ammunition including containers, and vehicles. It does not receive any assistance from private contractors. Some examples of the Branch systems are:

- TRITAC switch; a tri-service communication system
- TACFIRE; a computer system for artillery fire
- Bushmaster; a special purpose vehicle
- MICV; a mechanized infantry combat vehicle
- Copperhead; a laser guided projectile
- SLEEP; a family of silent lightweight generators

DARCOM is actually two groups - the Development part completely designs and procures equipment/systems while the Readiness group maintains the equipment turned over to it by the Development Command. It is similar to the Navy Ship Acquisition Project Manager (SHAPM) for new construction (Development) and the Navy Ship Logistic Manager (SLM) for operational ships (Readiness) where the SHAPM buys ships and the SLM's maintains them through their life cycles.

The Army cost model used by the Department of the Army Cost Directorate was discussed. It had originally been developed by McDonnell-Douglas for missiles. It has had many changes mathematically, but it is still basically the same. The present cost model uses some calculated percentages, factors and equations.

In developing costs, the Baseline Cost Estimate during the early stages of development is mostly parametric, but as the system approaches engineering development it becomes more engineering estimate (bottoms-up) oriented for equipment cost. Most of all, the other LCC cost elements are derived parametrically and look pretty much the same in both estimates.

The Cost Analysis Division has a review function in the Program Objectives Memorandum (POM) cycle. It also writes cost guidelines

for the Project Manager who prepares the Baseline Cost Estimate (BCE). This group also reviews the BCEs for costs and compares them with the Independent Parametric Cost Estimates (IPCE) developed either by the DARCOM or by the Department of the Army Cost Directorate for the Big Five.

The following observations were made:

- For the BCE, the cost data is hardware oriented.
- For the IPCE, the cost data is parametric/historical.
- The Cost Analysis Brief (CAB) for smaller systems and the Army Cost Analysis Paper (ACAP) for the Big Five are prepared to provide an in-depth, comparative analysis of the BCE and IPCE. The CABs and ACAPs are provided the Army Systems Acquisition Review Council (ASARC), the Cost Analysis Improvement Group (CAIG) and the Defense Systems Acquisition Review Council (DSARC) to aid in their decision-making process.
- While BCEs and IPCEs were being developed in the RDT&E stages, a source selection board was set up for the XM1 Tank which was completely independent of the BCE and IPCE groups and actually provided another (third) cost estimate.
- The IPCEs and BCEs are not used in the POM budget process. The POM cost estimates and BCEs are developed by the Project Managers.

It was said that the BCE/IPCE system had problems at first, but is now a good system and, ruling out inflation, has provided cost estimates within eight to ten percent.

The Cost Analysis Division (DARCOM) has been in the cost estimating/cost analysis phase for the XM1 main battle tank since its inception. This Division and the Directorate of Cost Anaysis people developed the original cost estimate for the XM1 which, according to the Division, has been within five percent of the incurred cost. The XM1 is presently in full scale engineering development and coming up for DSARC III.

This Division also reviews the POM/Budget estimates prepared by the Project Manager. In this way, they have a total awareness of the estimating process from product development, budgeting and production.

(8) Conclusions

Time and contract scope did not contemplate a complete review of the Army material acquisition procedure. By interviewing the chain for cost estimate development and review of a major program, it is believed that the principle thrust of Army's effort to be realistic in its cost estimates has been captured. From this review the following conclusions have been drawn:

- The Army has made a massive effort to improve its cost estimating ability since 1972.

- The basic Army estimating concept is LCC estimating.

- The BCE and Budget estimates draw heavily on contractor developed data for investment costs.

- The BCE estimates prepared by Army personnel on new systems are thoroughly checked by IPCEs.

- Budget estimates are prepared by Project Managers with assistance from contractors. These estimates are checked by cost analysts in the Comptroller of Army Office.

- The Comptroller cost analysts are not subject to pressure from the Project Manager to tilt cost estimates in favor of Project Manager' goals.

9. <u>THE OSD COST ANALYSIS IMPROVEMENT GROUP IS THE PRINCIPAL ADVISORY BODY TO THE DSARC ON COST RELATED MATTERS</u>

The Cost Analysis Improvement Group (CAIG) in the Office of the Secretary of Defense was established in January 1972 primarily as a result of cost growth of weapon systems of a magnitude of 100 percent to 200 percent. The CAIG function is to review and interpret project managers and military service independent cost estimates for presentation to the Defense Systems Acquisition Review Council (DSARC).

(1) <u>Department of Defense Directive 5000.4 Describes The CAIG Responsibilities</u>

The OSD Cost Analysis Improvement Group will act as an advisory to the DSARC on matters related to cost. Each member of the CAIG shall represent those functional areas which are in accord with

the standing organizational role and mission of his office. The specific responsibilities will include:

- Providing the DSARC with a review and evaluation of independent and program cost estimates prepared by the Military Departments for presentation at each DSARC. These cost reviews shall consider all elements of system costs, including procurement, operations and support as appropriate.

- Establishing criteria, standards and procedures concerning the preparation and presentation of cost estimates on defense systems to the DSARC and CAIG.

- Identifying to OSD functional offices and the DOD Components where efforts are needed to improve the technical capability of the DOD to make independent cost estimates of all major equipment classes.

- Developing useful methods of formulating cost uncertainty/cost risk information and introducing it into the DCP/DSARC process.

- Working with the DOD Components to determine what costs are relevant for consideration as part of the DCP/DSARC process and developing techniques for identifying and projecting these costs.

- Developing and implementing policy to provide for the appropriate collection, storage and exchange of information concerning improved cost estimating procedures, methodology and data necessary for cost estimating between OSD staffs, all DOD Components, and outside organizations.

- Providing an assessment or recommendations to the DSARC of all cost objectives prior to their inclusion in approved DCPs or similar documents giving direction to a DOD Component for the acquisition of a major defense system.

- Helping to resolve issues which arise over the comparability and completeness of cost data to be reported on new cost data collection systems.

- Accomplishing other tasks and specific studies as requested by the DSARC principles.

(2) The CAIG Is Composed Of Senior Officials In OSD Assisted By A Full Time Staff

The CAIG is composed of the following as of this writing:

	Office
Chairman	
Milton A. Margolis	PA&E
OSD Members	
George W. Sutherland Asst. Dir., Systems Acquisition Mgmt.	ODDR&E
Charles Cardiff Program Analyst, Acquisition Mgmt. Sys.	OASD(C)
Jacques S. Gansler DASD, Material Acquisition	OASD(MRA&L)
Col. Joseph Connolly Mil. Asst. to Dep ASD	OASD(MRA&L)
OSD Ad Hoc Members	
Nat M. Cavallini Directorate for Resource Mgmt.	OASD(C^3I)
Service Members	
Kirk Griffing Financial Management	OASA(FM)

Capt. Ralph Mason Asst. Cost Analysis Advisor	OP96D
Col. K. M. Oliver Chief, Cost Analysis Division	ACMC

(3) The CAIG Is The Top Program Cost Review Organization In DOD

Figure D.37 shows the heirarchy of program cost estimate review starting with the SYSCOMS being reviewed by OP96D and the final review and evaluation by the CAIG.

Figure D.38 shows the process of preparation and review of the Program Managers Estimate (Baseline Estimate) and the Service Independent Estimate. In the case of the Navy for ships, the PM estimate is prepared by SEA 01G in collaboration with the PM (SHAPM). The Independent Estimate is prepared by OP96D. The CAIG reviews the OP96D estimate and reports its findings to the DSARC for its evaluation of the Project Manager's estimate.

(4) The Independent Cost Estimates Are Parametric In Nature Based On Historical Data

The CAIG encourages the use of the parametric cost techniques for the preparation of independent cost reviews, rather than the industrial engineering or "grass roots" estimates used in industry. The parametric approach relates the actual historical cost of earlier weapon systems to

FIGURE D.37
HIERARCHY OF PROGRAM COST REVIEW

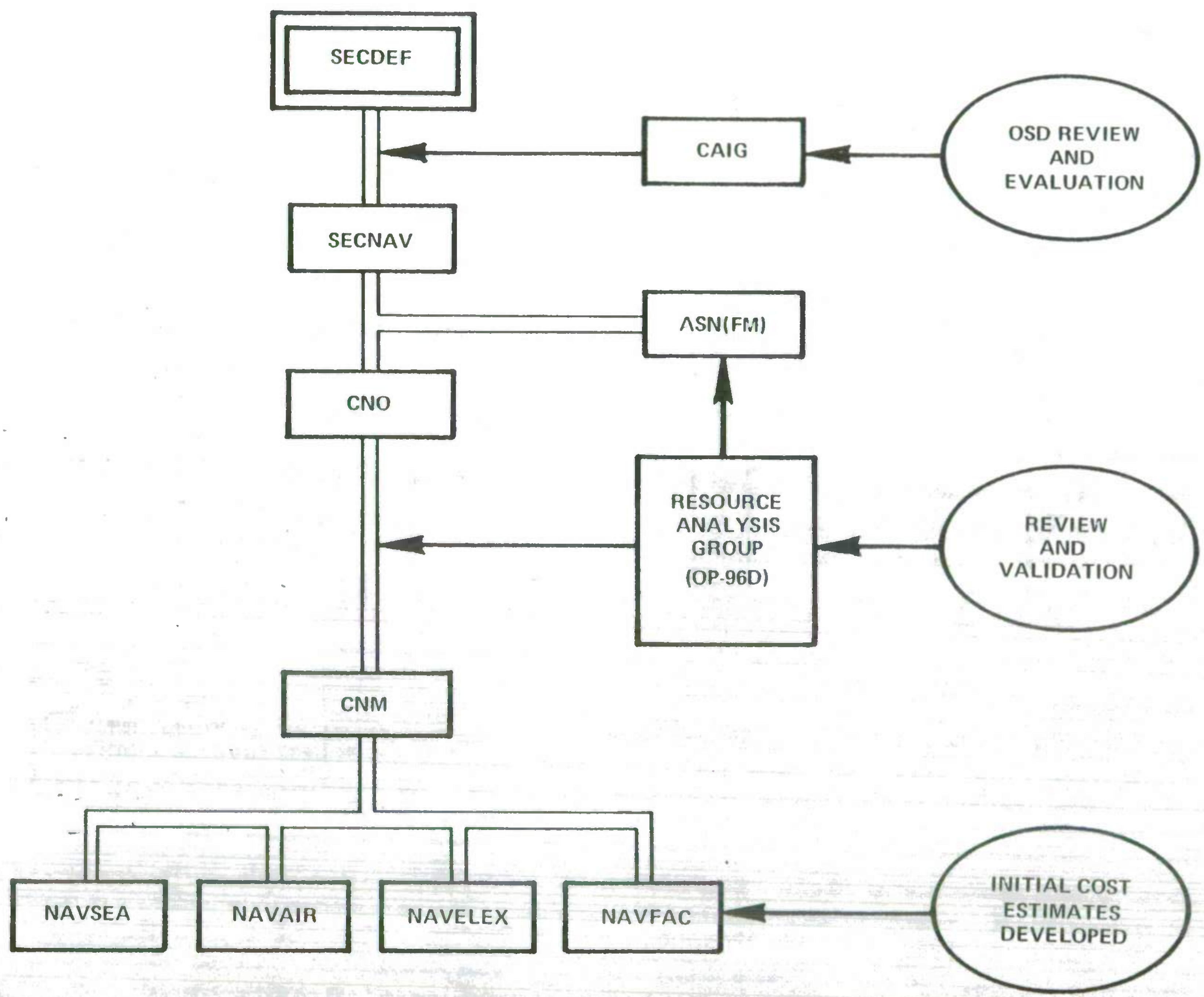
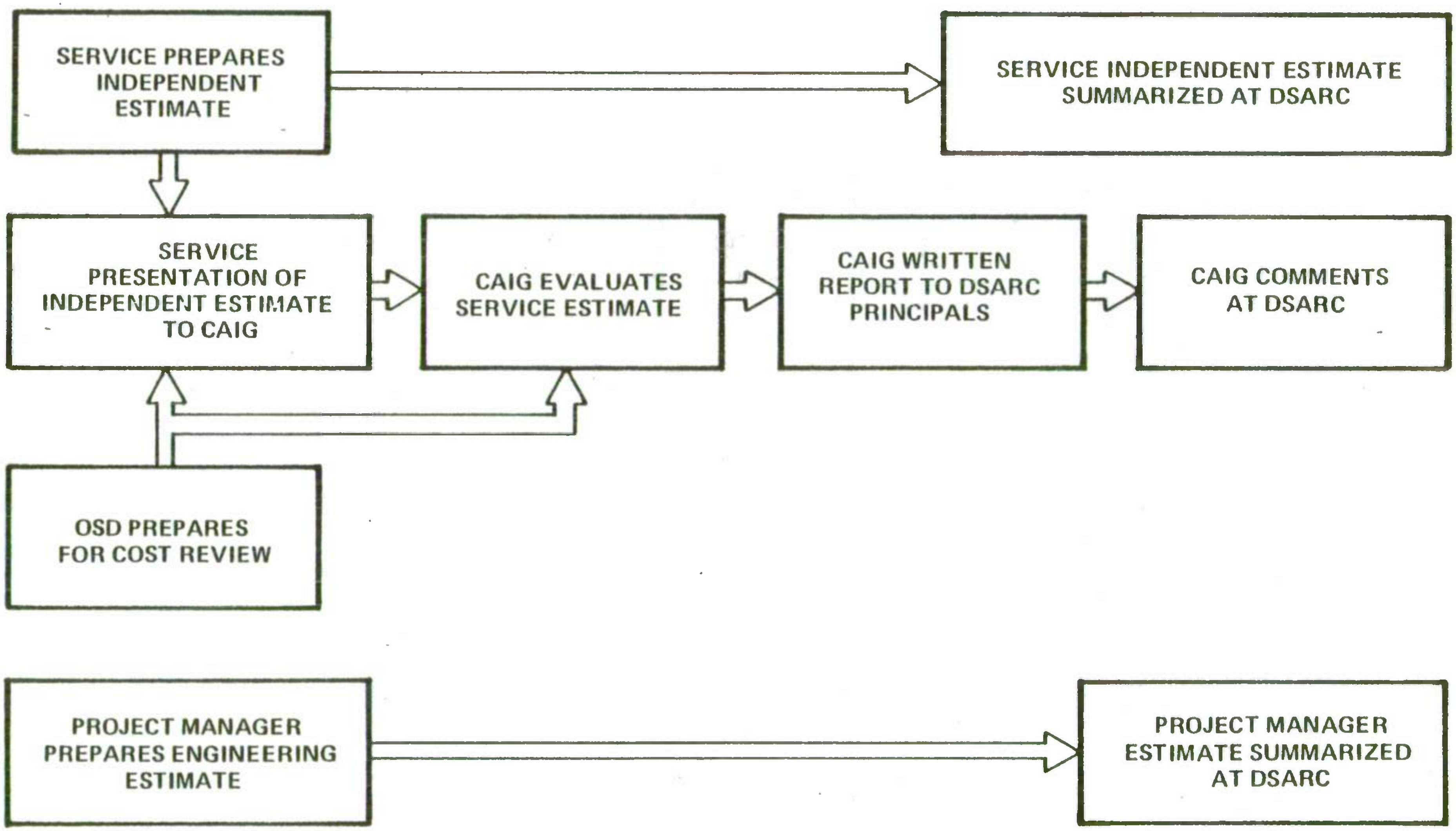


FIGURE D.38

SEQUENCE OF
INDEPENDENT COST REVIEW FOR DSARCS



their performance characteristics to make statistical projections of the most likely costs of new weapons. This approach is intended to capture the cost of setbacks and design changes encountered by almost all programs -- costs which are not usually anticipated in an industrial engineering approach. These most likely estimates are particularly useful in checking the reasonableness of the goals and thresholds used to manage and control weapon system acquisition programs, as well as to ensure adequate resources for major systems, which are provided for in the Five Year Defense Program.

Although independent analyses to date have tended to concentrate on the costs of acquisition, recent reviews have begun to also emphasize operating and support costs. The objective of these estimates has been to provide the DSARC principals with a perspective on the total resource impact of a given system and to distinguish properly between the costs of the alternative under consideration.

(5) <u>The Interview With CAIG Staff Indicates Care In Their Selection But Seems Short On Estimating Experience</u>

The CAIG staff consists of three civilians (GS 15s); one Navy Commander; two Navy Lt. Commanders; two Army Majors; and one Air Force Major for a total of nine. All members have Masters Degrees in various fields, two specifically in Operations Research in Systems

Analysis, one member a Ph.D. in Mathematics. The naval officers are 1110's which means that they are from the Fleet with a tour of three years with a possible extension of one year at the CAIG. The Army officers are from the Engineers Corps. The selection process for the military is very rigid. He must be nominated by his service; interviewed by the Chairman of CAIG, the Deputy Director of Resource Analysis, the Deputy Director For Strategic Programs and the team leaders in this directorate and finally an interview by the person the applicant would work with in the CAIG. The officers usually have not had cost experience before coming with the CAIG but have been outstanding students and officers.

Of the staff of nine, only five are full-time which would indicate that the level of effort placed on cost estimate review is being done in a highly aggregate and approximate manner. With respect to ships, they review estimates prepared by Project Managers and the independent cost estimate (ICE) by OP96D. In a few cases, they make their own ICE using historical data, analogs and regression estimates. For example, they made one on the FFG which took about three and one-half man-weeks of effort. Contractor Cost Data Reporting (CCDR) requirement is starting to provide historical cost data information. The OP96D Rand Model, which the CAIG used occasionally, had been updated in the fall of 1975 to utilize the return cost of ships on

a seven group basis. The problems of using the OP96D Rand Model was that it was formatted for a steam propulsion ship rather than nuclear or gas turbine and that it could not be used on weapon systems and electronics.

It is important to note that the CAIG does not review budget submissions; the same group (not staff) under their regular organizational responsibilities do. In most cases, the CAIG accepts the PM estimate which is reviewed in an informal atmosphere. CAIG does make an effort to determine if construction periods are reasonable and is well aware of the late delivery problem and impact on cost.

CAIG considers GFM estimates to be the weakest link in the estimating process and suggests making it mandatory that the PARMs provide complete documentation to SEA 01G when providing estimates. As it is now, it is impossible to track the development of the estimate.

(6) Even Though The CAIG Was Created As A Result Of Cost Overruns, It Does Not Review Budget Submissions

In DOD, the cost estimating process seems to proceed at two levels. The first level is concerned with new programs that must compete with one another to accomplish a mission on the basis of performance and LCC cost by way of the DSARC process. This is the stage

where the CAIG has been performing its function. In this process, cost estimates are prepared without any specific regard for the Budget process. It is quite possible for a ship budget price to go forward to Congress for a program well in advance of DSARC II when a preliminary design should be completed and as a result, the SHAPM/SEA 01G estimate is never checked against an ICE prepared by OP96D or the CAIG.

The second level of estimates are those prepared for the POM/Budget. These are specifically reviewed by the prescribed administrative layer, but are not checked against an independent estimate.

10. THE CENTER FOR NAVAL ANALYSIS (CNA) DOES SHIP ESTIMATING WITH A 60 ELEMENT COMPUTER MODEL

CNA does three or four studies each year as requested by the Chief of Naval Operations (CNO) or on their own for ships in the conceptual design stage. The ship estimating function is presently a one and one-half man effort made up of the director and part time assistance from a mathematician. For a specific ship/ship class they study affects of systems such as aircraft, ships, missiles and provides cost for different mixes of weapons and electronics. The cost estimates/analyses are used by various CNO groups as an aid in the selection process. These cost estimates were not "budget quality" but are based on a series of math models. Inputs to the cost model are performance specification

information such as speed and endurance taken from a large document titled "Code Ship - Payload Shopping List". The Code Ship model has a baseline date for material cost of 1968. The input for weapons and electronic costs are provided by SEA 01G. The model prepares estimates in a 60 element breakdown and has the ability to reflect the cost of space requirements for the different "pay load" weapon systems. It was stated that CNA had accumulated much technical data, including weight data from NAVSEC.

In a general discussion, the director stated that CNA did not have much confidence in the "return cost" information as, in their opinion, these costs included the problems encountered by a shipbuilder that would not necessarily be the same as those of another shipbuilder. CNA opinion is that contract bid information should be used in lieu of return costs since the expertise of many ship cost estimates would be compiled and averaged resulting in more accurate information.

11. THE BETHLEHEM STEEL CORPORATION IS A MAJOR SHIPBUILDER IN THE UNITED STATES

The Bethlehem Steel Corporation operates seven facilities in the United States and one abroad. Six facilities are primarily dedicated to ship repair and conversion and two to ship construction. The largest and most modern shipyard is located at Sparrows Point, Maryland. Currently, this facility is building a series of 265,000 DWT tankers. In the past, it has been primarily engaged in

building large merchant ships - both tankers and dry cargo. They have also built Naval auxiliary type ships. The last Naval ships built there were two Ammunition Ships (AE), the last one commissioned in 1971.

This shipyard is now doing about 150 million dollars worth of work per year and has a total employment of about 4,000 people.

The following report deals with what the estimating requirements are and how they are met. It also deals with the shipyard's general views on doing business with the Navy and what they regard as "cost drivers" in Naval ship construction.

(1) <u>In The Private Sector Shipbuilding Companies Are Required To Make Ship Construction Estimates In Two General Categories</u>

Private shipyard estimating departments are called upon to prepare rough estimates in response to customer inquiries and highly detailed estimates to respond to ship construction bids and proposals.

The preparation of these estimates is the primary responsibility of the individual shipyard's Chief Estimator of New Construction. Other shipyard or corporate departments are involved generally as follows:

- Sales Department

The general requirement leading to a decision to prepare an estimate originates in the Sales Department. The decision to proceed considers factors such as:

- Customer relations
- Can we be competitive?
- Is it a follow-on ship where another shipyard has the lead ship?
- Do we have necessary facilities?
- What is the status of present commitments?
- Is the job attractive?
- Does it make the best use of manpower?
- Does the estimating staff have sufficient time to prepare an adequate estimate?

. Engineering Department

The Engineering Department provides the estimate of engineering costs but also provides services to the estimators such as:

- Prepare general comments on specifications, including check on regulatory requirements (if not in-house design.)

. Purchasing Department

The Purchasing Department solicits quotations from manufacturers, advises on estimates of future escalation and gives general pricing information.

. Planning Department

The Planning Department provides the building schedule, required component lead times and manpower requirements by department and skills.

- Accounting Department

  This department provides a record of current contract costs and confirmation of projected labor rates, labor related costs, expense etc.

- Insurance Department

  Provides estimate of insurance premiums, and the cost of Payment and Performance Bond, if required.

- Production Departments

  The Production Department is called upon on an as needed basis to provide assistance in estimating unusual staging situations, fire protection plans, unusual lifting requirement, welding special materials. They also review the final estimate of manhours to discuss basis, special considerations etc.

- Legal Department

  This group is responsible for commenting upon contract provisions and to make proposed provisions.

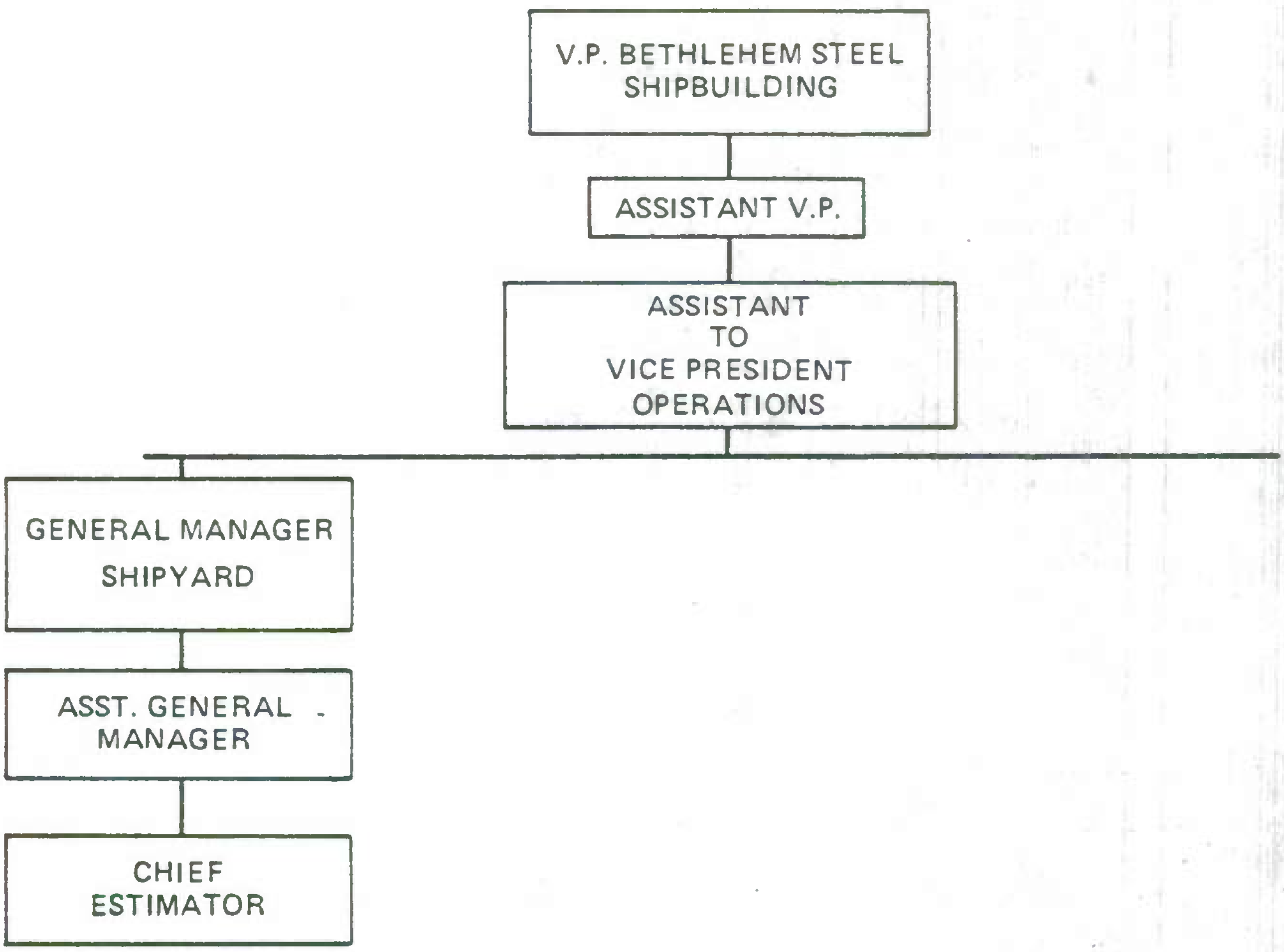
(2) <u>The Estimating Staff Is Located High In The Corporate Hierachy</u>

Figure D.39 shows the position of the estimating staff in relation to high officials in the Bethlehem organization. The arrangement places the Chief Estimator only one layer from the General Manager of the shipyard and four layers from the V.P. Bethlehem Steel for Shipbuilding. The Assistant to the V.P. Shipbuilding for Operations and Facilities is the principal review office before going to the V.P. for Shipbuilding.

FIGURE D.39

BETHLEHEM STEEL CO.
ESTIMATING ORGANIZATION

THE OFFICE OF CHIEF ESTIMATOR IS LOCATED AS FOLLOWS:



(3) Estimating Organization

The estimating organization of the Sparrows Point Shipyard is comprised of 20 estimators organized along functional lines as shown in Figure D.40.

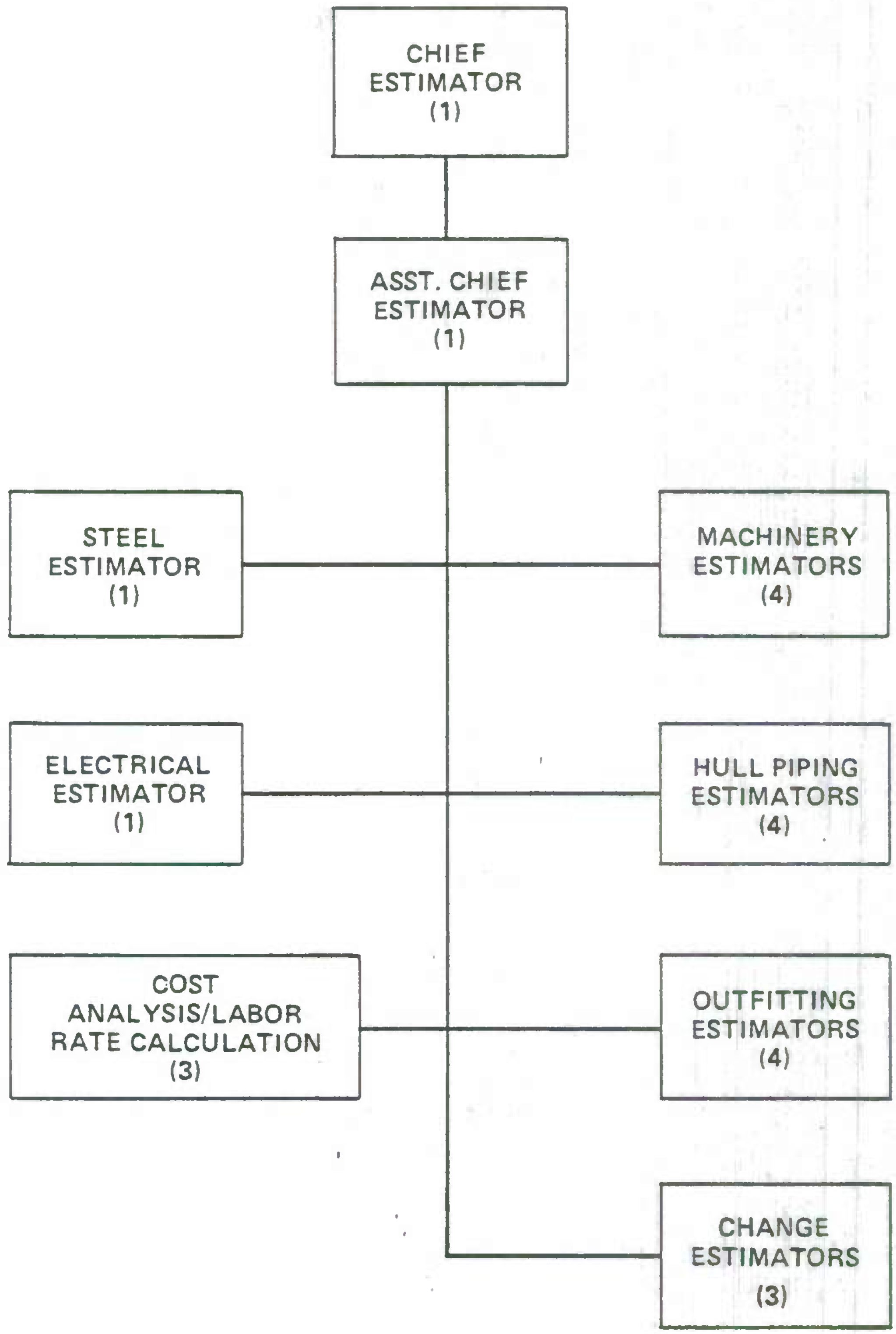
Bethlehem Sparrows Point Shipyard has a total of fourteen (14) new construction estimators. Generally the new construction estimators have specialized capabilities such as structure, piping, electrical, coatings, and various outfitting and machinery jobs. These new construction estimators also support and work on change estimates and Industrial Sales.

Bethlehem has two (2) change estimators. Recently they have been successful in pricing many changes on commerical work early in the contract period based on new construction estimating methods. This has been reducing the customary effort usually spent on changes, but there are always enough work to keep the change estimators busy.

The Estimating Department has three (3) people that compare the material budgets with actual material costs and provide management with predicted final material costs. A member of this group is a specialist on labor rate calculations.

FIGURE D.40

BETHLEHEM STEEL CO. PLACEMENT OF ESTIMATING ORGANIZATION



Resources used by these organizations are as follows:

- Personnel

  At Bethlehem Sparrows Point, the estimators have an average of 19 years experience as estimators and 29 years shipyard experience including estimating. The educational level is high school, shipyard apprentice training, and some college.

  The shipyard management feel strongly that, for the type of estimating they do, men with ship production experience are the best.

  The estimating department offers a career ladder as attractive as any other vocation in the shipyard. Several shipyard managers have arrived at that position through estimating assignments.

- Cost data

  The primary and by far most important source of data for making ship construction estimates is return costs. The return costs are gathered by Job Numbers. Each Job Number will gather manhours by department and by craft. Each Job Number embraces a discrete work package. For example, steel work which is Job No. 12, will be broken down into subdivision such as Job No. 129-5 (Innerbottoms), 129-9 (Bilge Unit) and so forth. This is done for all the other systems in the ship. With return cost recorded in this manner, accurate "will cost" estimates can be prepared for management review. Vendors quotations are used extensively to prepare bid estimates

- Technicol data (product definition)

  This material is usually provided by the prospective purchaser in the form of bidding plans and specifications or from the shipyards own engineering department when the prospective owner is buying a Bethlehem design such as the 265,000 DWT tankers.

(4) The Estimating Procedure Depends On The Purpose Of The Estimate, Product Definition And Time

The following description of the estimating process is an edited version of a description provided by Bethlehem.

- Type of new construction estimates

  Budget, order-of-magnitude or sometimes referred to as "quick and dirty" prices are generally called "approximate estimates". Usually the owner is only looking for a price range. Normally, insufficient data is available to support a firm price.

  - Generally these budget estimates require the basic design group (Central Technical Division) to prepare an outline specification. This consists of a page of general characteristics, and an outline sketch of the vessel with approximate weights.

  - The effort spent on budget estimates varies with the type of ship. If similar to other ships built or estimated, adjustments for type and size are made to suit present day pricing and conditions. This type of estimate can require as little as 15 minutes, as in the case of a rough price for a duplicate ship, or up to a couple of weeks including basic design and planning effort.

- Firm bid pricing which is usually supported by what is called a "Detailed Estimate".

  This type of estimating represents the major effort of the Department, and the following detail is directed to such an estimate.

  - What bidding information do the estimators get to work with? In the case of a Bethlehem design such as a tanker, about 250 pages of specifications and four (4) contract plans are available.

A recent cargo ship bid package designed by a private naval architect consisted of over 1000 pages of specifications, four (4) contract plans, seventy (70) contract guidance plans and other supporting information.

- A Navy drydock recently bid for and awarded to Bethlehem consisted of about 750 pages of specifications and about 25 contract plans.

- A Navy oiler will consist of about 1200 pages of specifications and about 50 contract and contract guidance plans.

- The invitation to bid may vary from a one (1) page letter as in the case of some commerical bids to 150 pages of invitation to bid and attachments as in the case of the Navy drydock.

- The Navy now provides as part of the bidding documents a Contract Data Requirements List known in its abbreviated form as CDRL. This lists all the "software" requirements listed in the specifications along with frequency of issue, distribution, etc. for such things as -

  Construction schedules
  Production progress reports
  Provisioning Technical Documentation
  Photographs
  Fire Protection Plan
  Welders Qualification Certification
  All Drawings
  Weight Estimates
  Test Procedures

  These items may require separate pricing:

- The Navy also provides a Data Item Description, known in its abbreviated form as DID. This lists the detailed requirement of items covered in the CDRL.

- The amount of time required to prepare a detailed estimate can be generalized as follows:

MarAd type construction	6 - 8 weeks
Naval auxiliary type	8 -10 weeks

This would also include special ships such as a dredge or LNG. In the case of a dredge or LNG additional time is required by the subcontractors quoting on special equipment.

Naval combatant type	13 - 17 weeks

During this period almost all of the estimating staff would be working on the project plus five to ten people from the Engineering Department. Subcontractors and major suppliers of equipment require up to three (3) weeks to provide firm prices. To illustrate the level of effort, it cost Bethlehem $600,000 to bid on the AO 177.

- The following estimates were prepared at Sparrows Point in the past year (1976)

  - There were 18 detailed estimates prepared:

    1 hopper dredge
    1 all container ship
    1 bulk/container/Ro-Ro ship
    1 chemical tanker
    7 tankers
    1 combination ore/oil ship
    3 drydocks
    1 sulphur carrier forebody
    2 barges of different types

  - There were 15 approximate estimates prepared:

2 segregated ballast tankers, different sizes
1 combination ore/oil carrier
2 barges of different types
2 chemical tankers of different sizes
1 OBO forebody
6 different cargo or bulk carrier types

In addition hundreds of special estimates and about 100 change estimates were prepared during the year.

(5) Bethlehem Estimating Procedure Is Characterized By Detail And Dependency On Return Cost Records

Estimates are prepared in accordance with Bethlehem's Job Number System. Material cost is accummulated by three (3) digit account number and actual return labor hours are accummulated by Department, by item number, as well as job number. This job number has the flexibility of being used for almost any type of ship. It has been used in estimating and accumulating costs for Naval ships as well as all types of commercial ships. The job number breakdown provides information from return costs enabling the estimator to apply costs at the various stages of construction.

The estimator concerns himself with weights, quantities of material required, present day material costs, and actual manhours to do the job or jobs as described by the job number book.

- The first step in the estimating process is to solicit vendor quotations. From the specifications, general clauses are prepared to be attached to all vendor and subcontractor inquiries. They include general particulars such as:

- Standards of workmanship
- Regulatory body requirements
- Noise and vibration requirements
- Spare part requirements
- Instruction book requirements
- Guarantee or warranty requirements

. The estimator generally takes off the material quantities and prepares the inquiry for purchased items. This assists the estimator in understanding the magnitude of the job and helps him in assessing labor while waiting for price information. Inquiries for purchased items include:

- List of quantities required
- Applicable specifications and plans
- General clauses

. Quotations when received are analyzed for price, delivery, conformance with specifications guarantees, engineering features, freight allowances, etc. Where information is not available from bidding plans and specifications, the estimator must layout or estimate by comparison from previous ships built for which he has returned cost information.

. In order to develop the actual estimate, the estimator is responsible for preparing and maintaining a record "Returned Costs" from ships previously built. The estimator also determines the actual quantities from the working plans of ship built. These quantities are used in developing estimating material and labor factors for each item or job as the case may be. Return costs help the estimator to develop:

- Net to gross ratios

- Unit costs of items not normally sent on inquiry

- Cost items that represent miscellaneous type materials for each job

- Unusual items of cost that may or may not be considered on future estimates

- To separate fixed charge type items

- To make comparisons with previous cost information to establish trends, learning curves, new requirements

- Prepare unit rates for estimating

. Returned cost information is recorded not only on ships built, but on ships being built. Information is thus received which compares hulls under construction to hulls completed at similar points of completion. The importance of returned costs cannot be emphasized enough. In the case of a new item where factors are not available from returned costs the estimator would probably approach the job on a number of basis. The estimators would first endeavor to apply any parts of returned costs from various ships to similar parts of the estimate under preparation. He would also estimate under preparation. He would also estimate on the basis of the number of men and length of time required to accomplish the work. Additionally, the estimator would seek any available total cost for systems used in other ships of different types where a valid comparison exists.

. The estimate is then done by job number using quotations, given quantities and labor and material factor developed from return costs. The results are then presented in a summary. Each job number or group of job numbers is totaled showing weight, material dollars and labor hours. Reference to price source and other pertinent information is noted.

Job number totals are then carried to the Hull and Machinery Summaries and totaled. This is then summarized on a sheet called Summary of Material and Hours, which includes these elements:

- General characteristics are noted

- Total weight is estimated and comparison with the design agent information shown

- Weight, material, and labor hour factors shown here are used in overall checking, to establish and provide a ready basis for budget estimates

- Fixed charges or non-reoccurring items are added

- Unusual items or special considerations are added

- Adjustments are made for following ships as necessary

- Material listed on this sheet generally represents a particular base month and this is so noted

- Finally an allowance would be made for a learning curve or drop curve. Years ago significant drop curves were provided for but for the last several years experience has not supported the existance of drop curves for ships under construction and for those now being bid for.

. Another less detailed estimate summary is made which includes the following elements

- Base month price

  A less complicated estimate summary to prepare would be that for a base month. The following is noted:

  Material is broken down into items that lend themselves to the application of escalation.

  Labor rate is applied using a rate that should represent the base month. Usually normal rates and overtime/shiftwork rates are shown.

  Expense rate based on the value for the construction period applicable to the particular estimate (considering the yard force that is anticiapted to exist at the time this construction would be occurring). Expense dollars are developed by the shipyard with corporate Accounting Department assistance. The yard force that is anticipated to exist is developed by the shipyard with corporate assistance.

Generally the Owner requests a delivered cost as well as the base month cost.

- Labor rates - (for either base month or to suit delivery schedule.)

  Periodic rate projections are provided by the home office with current information consisting of the following:

  The Accounting Department record of the actual rate which is compared with latest projection.

  Each estimate is weighted by shipyard divisions in establishing the total rate to be applied for each estimate. Divisions are structural, machinery/outfitting, material/service and loft/optical.

  Each element of rate is reviewed for each estimate revised to suit conditions such as -

  Will additional overtime or shift work be more or less?

  Is there any indication of base rate creep? i.e., laying off-keeping high paid workers

  Was the effect of the labor agreement assessed properly?

  Are incentive payments following past trends?

- Delivered price or combinations

  Material

  Steel: percent applied based on best judgment of Estimating Department, General Manager's Office and Vice President's Office

Engineering: rate is escalated similar to yard rate

Fixed Items: these items would not be escalated provided they meet the required delivery schedule

Other Quoted Material: If vendor quoted to a different delivery schedule or expressed his escalation conditions, escalation then must be calculated as necessary

All Other Material: percent applied based on best judgment of Estimating and Purchasing at the time

Centroids for material are established based on historical information

On Navy work further escalation compensation is necessary due to -

Navy escalation clause mandated percent subject to escalation is usually too low

Navy formula provides for no profit on escalation

NAVSEA indices are not currently weighted properly to suit most ship construction

- The final estimate as prepared by Bethlehem reflect actual cost, past and current, and present to management a cost platform from which a bid can be based. The Chief Estimator presents his estimate to the Assistant General Manager. From there it is reviewed by the yard General Manager and is sent to the corporate office for pricing. The pricing is done by the Vice President's Office. Pricing involves adjusting the "will cost" estimate for overhead rate, profit, market and/or other margins for such risks which are not compensated for by escalation, etc.

(6) <u>There Are A Number Of Special Considerations That Affect Bethlehem's Estimates</u>

- Inflation escalation

  Estimating allowances for inflation, in the sense that it measures cost growth from time the cost factors are considered in the estimate to the estimated time of award, are minimized by using vendor quotations and knowledge of their own future labor costs in accordance with their union agreement. Some judgmental consideration, however, must be made regarding overhead, or any pending legislative action that may affect cost.

  Escalation during the construction period is treated in two parts. First is the portion of escalation that management believes will be covered by contract provisions. The second consideration is to calculate a margin to take care of cost escalation that will not be covered by the contract. Bethlehem believes the current Navy index should be revised by BLS (Ref. recent letter from MarAd to BLS) to reflect fringes in labor cost.

- Form of contract

  Each form of contract is very carefully analyzed with respect to terms and provisions that involve risk and cost.

  Considering the types of contracts currently being used, a contract made with a private customer without government involvement is most advantageous. The private contract can include a substantial down payment at contract signing and almost total protection for labor and material cost increases during the construction period.

  The second contract preference is the MarAd contract form and lastly the Navy form of contract.

- Doing business with Navy

  Doing business with the Navy involves special risks not found in commercial or other government work. First,

the Navy contracts offer protection for about two-thirds of expected escalation. Second, there is a need for proper appreciation of the requirements of business by Navy top management. Third, the risk involved in interpreting Navy and Mil specifications.

- Social legislation (OSHA, EPA, EEO Longshoremen's and Harbor Worker's Compensation Act)

  Bethlehem believes OSHA costs about one percent or $1,000,000 on a $100,000,000 ship. The added expense for these requirements is reflected in direct costs, increased overhead and lower productivity.

- Amortization of capital improvements

  In general, Bethlehem believes, like most industry, that capital improvements should be paid out over a relatively short time, depending on the nature of the investment.

- Productivity loss

  The Bethlehem experience with steel trade labor productivty during recent year has been about three percent per year in spite of the introduction of labor saving facilities. A correlation was found between productivity and the percentage of first class workers to second class and third class. When the percent of first class workers increases productivity increases. Productivity for outfitting and machinery trades has not been similarily affected.

- Profit

  The assignment of profit to bids is a top management decision that entails consideration of market condition, yard workload, ship type, etc.

(7) <u>Indentification Of Principal Cost Drivers In Naval Ship Construction</u>

Bethlehem believes the principal cost drivers rest with the Navy's contracting procedure and the specifications, with particular reference to

numerous Mil Specs. The contracting procedures are such that the Navy tries to get ships for bargain prices by making the award to the low bidder whether capable or not. This very often leads to delay, disputes and claims.

12. NATIONAL STEEL AND SHIPBUILDING COMPANY IS A NEWER MAJOR SHIPBUILDER

National Steel and Shipbuilding Company (NASSCO) is a relatively new shipyard in the large ship construction field. Since 1970, NASSCO has built numerous subsidized cargo ships, Naval auxiliary ships, LSTs and tankers. Currently (August 1977) it has seven tankers under contract and two destroyer tenders (AD41 - 42). (The AD 43 was awarded to NASSCO in October 1977.)

NASSCO is currently doing about 150 million dollars worth of work per year and employs approximately 6,500 people.

(1) An Interview With The General Manager, Sets The Tone For NASSCO's Views On Navy Shipbuilding

According to him it would be impossible for the Navy to estimate ship construction costs four to five years in advance of construction because the ship is not well enough defined. For example, on the AD 43 for which they are currently bidding, the RFP is late due to spec changes and a modification (MOD 1) has already been issued (700 pages). In addition, another 300 page instruction has been issued. He understands MOD 2 is underway. On AD 41 and 42 changes are already $4 million

and progress is less then five percent (January 1977). The contract price is about $300 million.

Concerning the current escalation provision in Navy contracts, the General Manager consider the material index and labor index to be fairly adequate, but wholely inadequate for labor fringes, i.e., social security, unemployment insurance, health benefits, etc. The opinion was expressed that overhead should be escalated by some percentage of the BLS labor index - like 110 - 120 percent, to be adjusted annually. He also feels that the 100 percent of overhead should be subject to escalation instead of 75 percent, which is the current practice.

Regarding capital improvements, the study "Profit '76" is considered to be inadequate. National Steel philosophy is to pay out a facility cost by work under contract so that there is no risk. This way, after the contracts are complete the improvements are paid for and they will enhance their profit position on future work.

The General Manager went into the NASSCO bidding process. The estimating department makes an estimate giving manhours and material cost as of a certain date (or month). This is then reviewed by a Management Committee, chaired by the General Manager which decides the labor rate, overhead, escalation and profit. It is understood that the staff

prepares material on these factors for committee use. Before a bid can be made, stockholder approval is required from Kaiser and Morrison Knutsen, the parent companies, for everything over $10,000,000. The General Manager considers the continual flow of changes and the mountain of paper work to be a major cost driver.

(2) The Requirements For Preparing Ship Construction Cost Estimates

The visit to NASSCO included the following review of estimating procedures, organizational structure, and cost drivers.

- Estimating Department

  The Estimating Department is responsible for preparing all ship construction estimates and changes. They have a separate ship repair estimating group. The Estimating Department is now spending about 50 percent of its effort budgeting time and material for a cost and production control system being developed to implement DOD Inst. 7000.2. This is up from 10-15 percent several months earlier (September 1976). The current distribution of work in the Estimating Department is:

  - Labor and material budgeting for DOD Inst. 7000.2 - 50 percent. This is done by the estimators with a production background
  - Changes under the contract - 25 percent
  - New construction estimates, make or buy determinations along with industrial sales estimate - 25 percent

  For a new commerical ship construction they will spend from 6,000 to 10,000 manhours on bid estimates. This will usually involve 15 people over a three month period, including about five engineers. For an AD, about

twice the effort is required. The Estimating Department also will send out about 1,200 requests for vendor quotes on material and subcontract services for a Navy proposal.

- Engineering Department

  The services of the Engineering Department is essential to good estimating. They develop design criteria for pipe and cable sizes needed for accurate material take-off. They assist in the compilation of bills of material and review vendor quotes for compliance and completeness.

- Accounting Department

  The Accounting Department develops criteria for overhead and labor rates.

- Planning Department

  The Planning Department develops a detailed construction schedule which includes an overall manpower distribution schedule showing the proposed work impact on current work. This is generally done for each labor skill on a Navy proposal. The Accounting Department uses this material to help determine what the overhead might be and the labor rates to use.

(3) Position Of The Estimating Staff In The Corporate Hierarchy

Organizationally, the Chief Estimator is only one level removed from the Executive Vice President and General Manager. All his work goes through the Director, Operations and Planning. The final estimates are prepared after the Management Committee (see General Manager's interview) has determined labor rate, overhead, escalations and profit.

(4) The Cost Estimating Function At NASSCO Emphasize Personnel With Practical Experience And Reliance On Return Cost Data

One of the major resources for cost estimating is personnel with practical experience. The second is an accurate and timely system for reporting return costs in a manner useful for cost estimating and production control.

- The estimating staff of this shipyard is relatively young, almost all under 40. The Chief Estimator is only 34, with about nine years of estimating experience. NASSCO feels very strongly that its estimators should have an engineering background, with emphasis on design. They do not consider theoretical engineering to be as relevant as design to the type of estimating they do.

  Figure D.41 shows the internal organization and staffing of the Estimating Department. This shows four sections, Labor Budgets, New Bid Proposals, Hull Steel and Outfitting, New Bid Proposals Mechanical and Electrical and new construction change orders. The general education and experience of staff follows:

  - Chief Estimator (1)

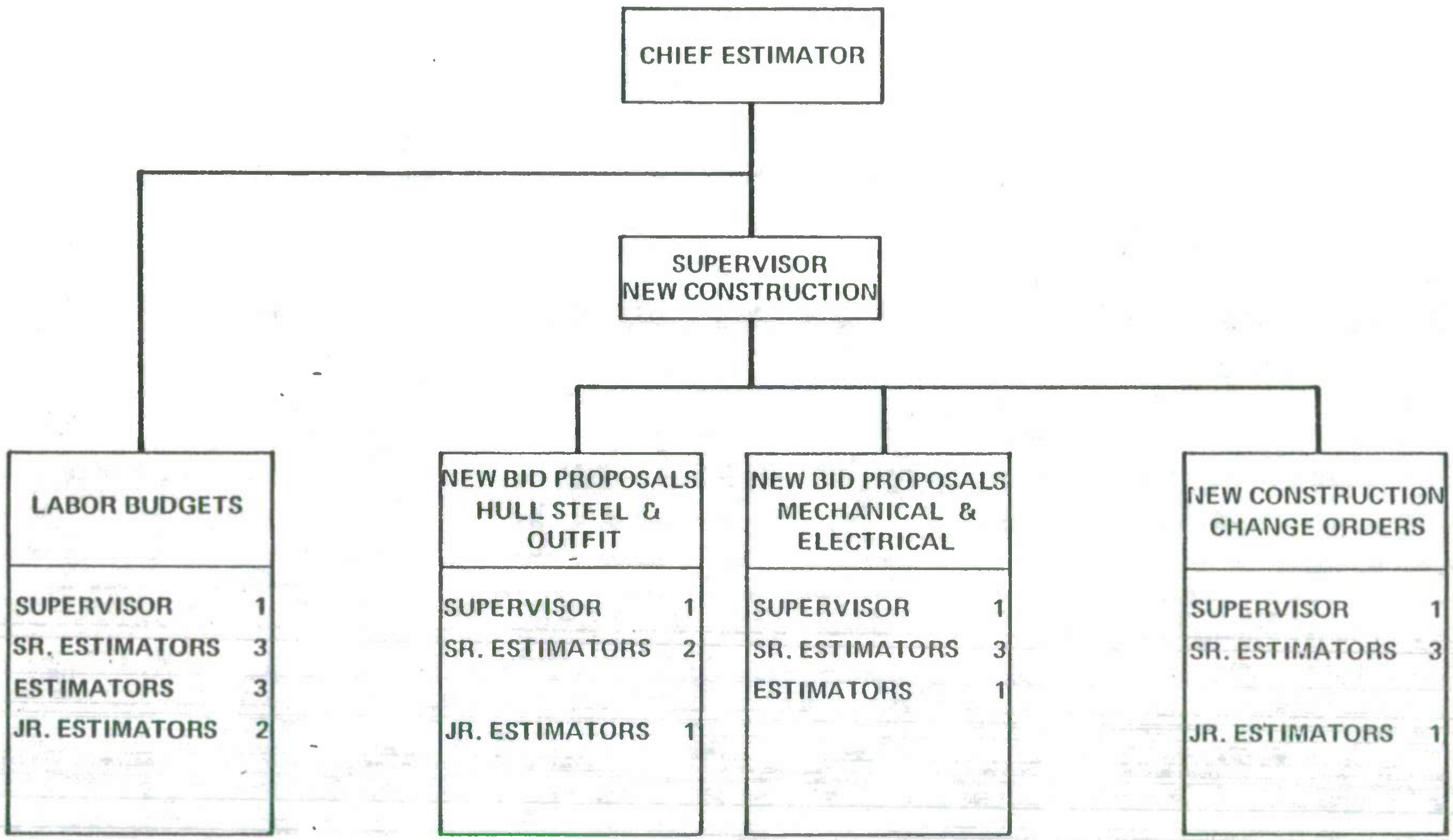
    Age: 34
    Education: 4 years training; Associate Degree in mathematics; lacks 16 credits for BS in finance.
    Experience: About five years in engineering as a designer (not prof. engineer); ten years in estimating of which six were as a supervisor.

  - Estimator Supervisors (5)

    Age: 38-40, one 52
    Education: three have college degrees in engineering; two have only high school plus some vocational school.
    Experience: have about eight years in engineering; also have a minimum of three years in estimating, six years maximum.

FIGURE D.41

NASSCO ESTIMATING DEPARTMENT ORGANIZATION



- Senior Estimators (11)

  Education: high school plus some commerical college training
  Experience: minimum of five years engineering; estimating experience is two-four years

- Estimators and Jr. Estimators (8)

  Education: high school
  Experience: engineering three years; production four-five years.

. Cost data is developed in a variety of ways described briefly below.

- Returned Costs

  For its data bank, NASSCO relies most heavily on returned costs from both finished work and ongoing work. They collect returned costs by process in the same manner as they build the ship. The cost record for the steel is broken down to identify fabrication, assembly, and erection for decks, bulkheads, stiffened units, bow and stem. For piping, they record returned costs by system for work done in the shop and on board ship.

. Product definition is regarded as being of paramount importance to accurate estimating.

- Engineering Office

  The engineers are used primarily to expand upon bidding plans and specifications with sketches of piping, wire, HVAC systems, etc., to assist in making take-off and labor estimates.

- Shops

  Used for configuration of estimates where return cost are not available.

- Purchasing Department

  Not used very much directly, but Estimating Department has copies of all material requisitions and purchase orders.

(5) NASSCO Relies On Detailed Cost Estimates For Bid Proposals Using As Much As 23,000 Manhours In Their Preparation

For sale inquiries or for "order of magnitude estimates" the detail could range from a few hours on a repeat design under construction to two man-weeks preparing an estimate with 70 elements in the WBS. It was said that budget estimates took from two - eight man days.

For bid or proposal estimates they go into great detail expending from 18,000 to 23,000 manhours to prepare the bid on the AD 41. Depending upon the complexity of the ship, a bid estimate could have from 5,000 to 10,000 significant labor entries. The following summarizes the important consideration that go into the estimate for direct, indirect and overhead costs.

. Direct

  - Labor

    Labor estimates are developed from returned cost on similiar jobs completed and on going work.

  - Material

    Quotations from vendors are used whenever possible. Lacking quotes, returned costs are used with factors for inflation.

- Indirect Cost

  - Ship Services

    Returned costs are used taking into account ship size and construction time.

  - Supervision

    Supervision is taken as a percentage of direct labor. The first level of supervision which in non-working is the foreman who supervised from 20-50 workmen on tools.

  - Energy

    This includes electricity, compressed air and fuel, etc. These are estimated from returned costs taking into account time, ship size, and manloading.

- Overhead

  Overhead determinations are made by the Comptroller's office. This office makes a continuous forecast of overhead using several possible ongoing work loading. On capital improvements, the cost of financing is carried in overhead. This will not mean an increase in total operating cost, however, because of the saving in direct manpower occasioned by the investment or because increased business will be generated by the capital expenditure.

(6) <u>The Chief Estimator Is Only Two Management Layers Below The Decision Making Level</u>

The Office of Chief Estimator is under the Director of Operations and Planning who is turn answers to the Executive Vice President and General Manager. Since the management committee, headed by the

General Manager, determines important elements in the estimate such as the labor rate, overhead rate, percent escalation and profit, it could be said top management really makes the dollar estimate. This estimate may or may not be reviewed by the stockholders.

(7) NASSCO Gives Careful Attention To Special Estimating Considerations Such As Navy Form Of Contract

It is the NASSCO practice to prepare a bid based on prices of a certain day. Depending on economic conditions at the time, a bid on this basis is good for 60 to 90 days. This time period is also influenced by how long major vendors will fix their quotes.

Bids that are subject to adjustment for escalation of labor and material must be adjusted by an amount which will cover what they believe will be the difference in the amount they will receive through the escalation provision and their actual cost. This is practicularly true for labor where the BLS index ususally shows a gradual increase due to averaging many yards, yet any single yard has a labor increase in steps.

- Form of Contract

  It is readily acknowledged that the Navy has unique problems not generally found in the commerical world. Generally, Naval ships are more complicated. Their service requirements do justify, at least to some extent, unique reliability requirements. In order to accommodate these characteristics, unusual contract clauses

are necessary. An opinion was expressed that many of the contract clauses stem from the Navy's inability to control its own employees and is transferring the burden to industry. The example cited was the "no claim clause".

- Doing Business with the Navy

Doing business with the Navy is diffcult. The specifications are most onerous because of the numerous references to Mil Specs, many of which turn out to be out of date or unavailable. The specifications are involved and require very careful reading to avoid getting caught in an obscure requirement. In this regard, NASSCO provided a copy of a suggestion presented to the Navy. This suggestion sets up a non-profit group to review NAVSEC actions. (See Exhibit D.4, Aid To Naval Procurement).

Another irritant is the Board of Inspection and Survey that conducts the Navy acceptance trial. This board is inclined to be very exacting and abrasive.

The frequent rotation of Naval officers in the Supervisor of Shipbuilding Office also makes doing business with the Navy difficult. In numerous instances, the attitude taken in Naval correspondence toward the contractor is abrasive and makes doing business generally difficult. Navy inspection is very stringent compared to commercial practice. The Navy can have as many as 50 inspectors on a Destroyer Tender (AD) compared to three owner inspectors for a large commerical tanker, plus part time for ABS and USCG inspectors.

- Social Legislation (OSHA, EPA, EEO, Longshoremen's and Harborworker's Compensation Act)

NASSCO does not make special allowance for future cost of social legislation. It does, however, take these costs into account as they are reflected in returned costs. As an example of a recent development, an added cost is the requirement of last year to make special provisions to hire the handicapped and the mentally retarded.

- Amortaization of Capital Improvements

  For substantial capital improvements, NASSCO must have contracts in hand to charge them against. The study, "Profit '76" may be suitable for product manufacturing like cars, but not shipbuilding.

- Material Delivery

  Not currently the problem it has been in the past. Currently, material is being delivered on time as required by purchase order.

- Productivity

  NASSCO is well aware of influences that affect productivity and attempts to take these into account. Productivity is affected by such things as labor build-up, training, turnover, EEO, etc. Productivity studies and evaluations are made for each trade based on past experience and judgment. Presently, they think at NASSCO that productivity has stablized after a period of deteriorization. NASSCO has also found that productivity can be greatly affected by capital improvement that disrupts the yard.

- Profit

  Profit is strictly a top management decision.

(8) Cost Drivers Are Quite Evident In Naval Ship Construction

There are many cost drivers in shipbuilding, but the following were considered important to NASSCO.

- Mil Specs - Mil Q in particular, is not necessary.
- Documentation CDRL requirements; paperwork is really excessive.

- DODINST 7000.2 requirements are excessive.

- Lack of responsiveness to value engineering proposals. On AD 41, some $6M is value engineering changes were proposed by the shipyard and not one was accepted by the Navy.

- Navy standards for materials and components, in many cases, are no better than commerical, but cost more.

- The risk involved in Navy Specs language and Mil Spec referencing.

NASSCO has prepared a proposal (Exhibit D.4) which has been given to the Commander NAVSEA suggesting how to reduce many of the problems presented by contracting with the Navy.

(9) Miscellaneous Points

- In the same time frame, the Navy will treat shipyards differently with respect to contract provisions on similar ship types.

- When NASSCO converts its bid to the Navy three digit systems as required by the contract. Some accuracy is lost but they do the best they can.

- NASSCO would never estimate a ship on the single digit system if it could possibly help it. It is too gross.

13. NEWPORT NEWS IS PROBABLY THE LARGEST AND MOST DIVERSIFIED SHIPYARD IN THE WORLD

The Newport News Shipbuilding Corporation (NN) is located in Newport News, Virginia on the James River. NN has a current total employment of

approximately 23,000 people and are currently building CVN, CGN, SSN and LNG ships. In addition, they have an extensive naval ship overhaul and ship repair capability.

The Newport News yard is devoted to naval ship and commercial ship construction and is one of the oldest in the United States and covers 330 acres making it one of the largest shipyards in the world. In 1973, it started a new facility adjacent to the old yard designed to accommodate tankers up to 1,000,000 DWT and LNG carriers.

(1) The Newport News Cost Estimating Staff Is Geared To Doing Detailed Engineering Estimates

Although NN must prepare estimates for a variety of reasons, the major effort goes into three kinds of estimates.

- Idea Price/Budget Price -- Newport News does, on occasion, prepare this type of an estimate for a commercial customer. These estimates are considered to be 5 to 10 percent accurate and tend to err on the higher side. The time taken to do this type of an estimate is from one day to a week, depending upon how real the job is, the type of ship and how close the design is to one previously built.

  They made the point that they do not do this on Navy work because any future change in price is cause for a justification of the difference, from both Newport News top management as well as the Navy.

- Proposals/Bids -- These are detailed engineering estimates that usually take 90 days to prepare. For example:

- Follow on Sub 20-25,000 manhours
- CVN 50,000 manhours
- VLCC 10,000 manhours

. <u>Cost to Finish</u> -- Cost to Finish Estimates are made in order to arrive at a total cost of work under construction, so that the follow-on estimate can be made for a similar or sister ship.

(2) <u>The Ship Cost Estimates Require Input From A Number Of Other Departments</u>

The total shipyard effort to prepare a proposal or bid requires the participation of at least six other major departments.

. <u>Accounting</u> -- The accounting departments participation in the cost estimating function is to provide Base Month Labor Rates for engineering and production labor, and to forecast overhead cost as a percentage of direct labor. Overhead is calculated separately for different product lines, i.e., commerical shipbuilding, naval shipbuilding, repair, and non-marine.

. <u>Engineering</u> -- The engineering department provides the estimate of engineering manhours and does the steel take-off for steel weight and sizes. In addition, they provide services as required in the following areas:

- Interpretation of technical requirements
- Develop equipment sizes
- Prepare quotation inquiries, technical description

The Cost Engineering Department does as much in the three areas mentioned as possible before calling upon engineering for assistance.

. <u>Purchasing</u> -- Purchasing sends out requests for quotations on material units as requested, generally of

$10,000 or more per unit in value. They also provide general information on price movement, i.e., inflation, delivery conditions and other general intelligence on material procurement matters.

- Operating Departments -- These departments are not used very much, primarily because they are usually overly optimistic on what they can do a job for. Experience has found them estimating jobs at about 60 percent of actual cost.

- Legal/Contract Departments -- The estimator works very close with the legal/contract offices to screen RFP for cost sensitive requirements and to keep abreast of legislation that may have an impact upon ship cost.

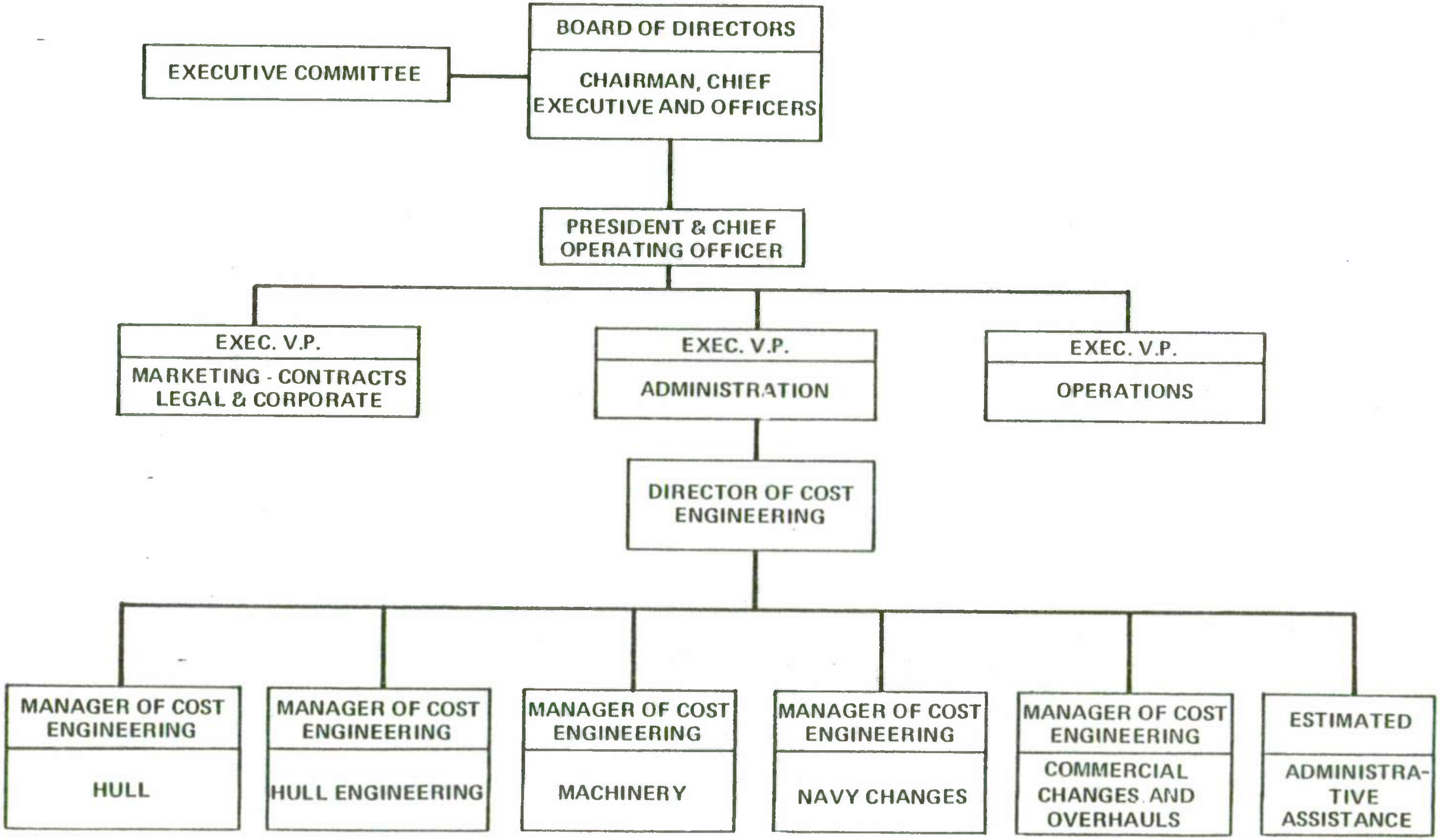
- The shipbuilding schedule is given to the estimating department by Production Control.

(3) The Cost Estimating Staff Occupies A Prominent Position In The Corporate Hierarchy

Figure D.42 shows the position of Director of Cost Engineering to be only one layer of management removed from President and Chief Operating Officer and under the direct supervision of the Executive Vice-President for Administration.

The Director of Cost Engineering is given the wide authority to develop ship cost estimates which include labor rates and overhead. The Director's estimate is a "will cost" value without a profit selection. The final approval of the estimate and the selection of a profit or fee target is made by top management consisting of Chief Executive Officer, President, and Office of the President. The highest detail

NEWPORT NEWS SHIPBUILDING CORPORATION



review given the estimate is by the Executive Vice President for Marketing/ Contracts/Legal and Corporate. The estimators, therefore, determine cost and management determines price. There is no corporate input from the parent company, Tenneco.

The estimate review is often in the form of presentation, which sets for the rational for all estimate assumptions and how the estimate was developed, i.e., base ship, overhead analysis, productivity, labor rates, manpower requirements, etc. The presentation also shows a profit selection analysis which top management considers in selecting the profit value to be included in the final proposal.

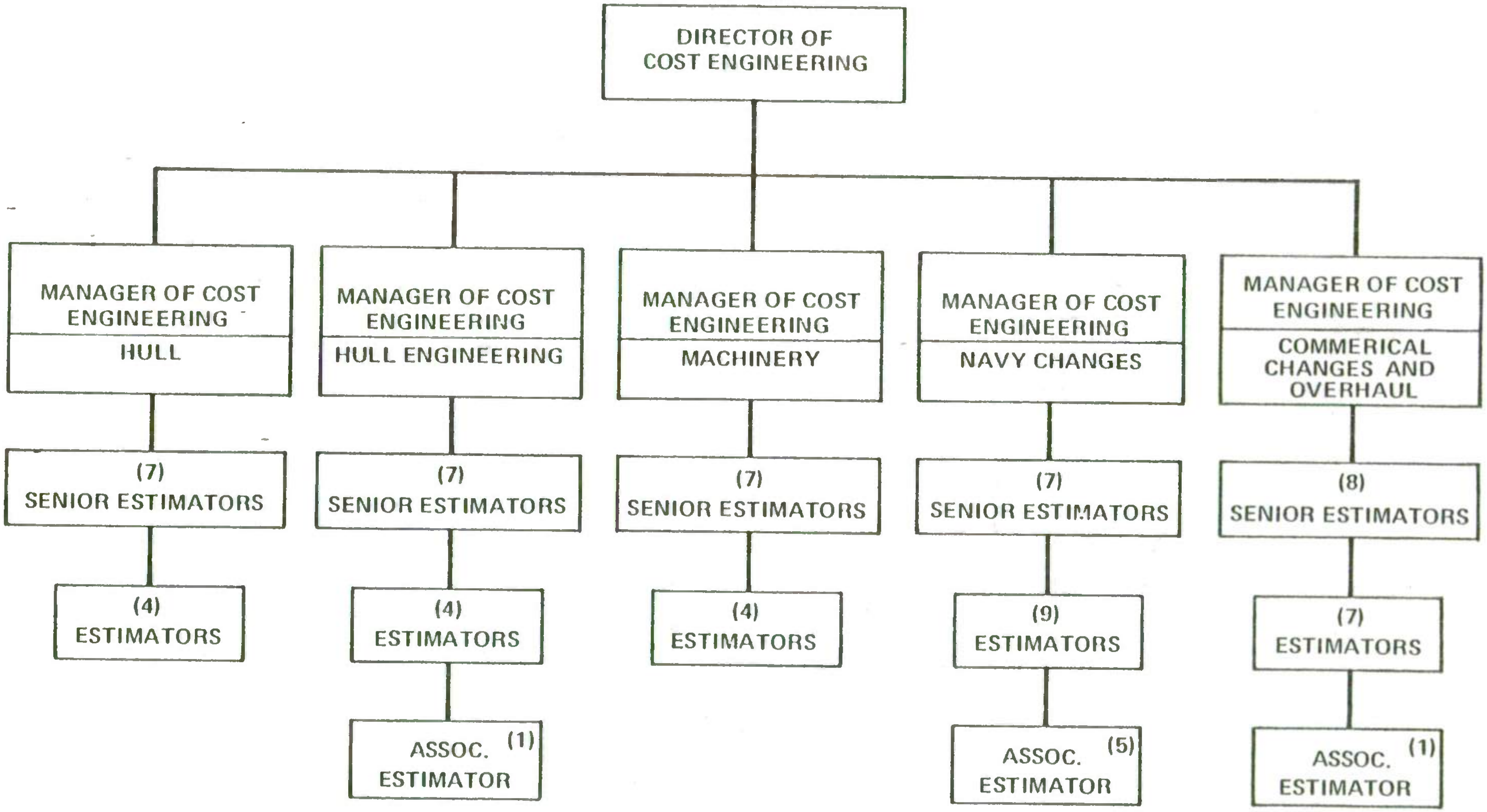
The organization of the Office Director of Cost Engineering is shown on Figure D.43. About one-half of the professional staff (37 people) work on new ship construction, major overhaul, major design and miscellaneous proposals. The other half work on new ship construction changes, Navy overhaul change estimates and various assignments.

The cost engineering resources at NN are impressive, but no more than expected for a shipyard with such a wide range of capability and current contracts.

- Personnel -- In new ship construction, the professional personnel is as follows:

FIGURE D.43

ORGANIZATION OF COST ESTIMATING FUNCTION NEWPORT NEWS



PROFESSIONAL STAFF

1	DIRECTOR OF COST ENGINEERING
5	MANAGERS OF COST ENGINEERING
36	SENIOR ESTIMATORS
28	ESTIMATORS
7	ASSOCIATE ESTIMATORS
1	ADMINISTRATIVE ASSISTANT

- 3 Managers
- 21 Senior Estimators
- 12 Estimators
- 1 Associate Estimator

The staff have an average of 28 years shipyard experience and 11 years in estimating. Almost all have graduated from the Newport News Apprentice School and about one-third have Engineering degrees from Virginia Polytechnical Institute, North Carolina State University, University of Michigan, or other major engineering schools. Their shipyard experience has been either in design or a trade. At Newport News, it is considered a privilege to be on the estimating staff and all have come into estimating by their own choice.

The remaining staff of 40 are associated with Navy new construction, Navy overhaul and commercial ship changes. These functions are a direct charge, where the preparation of bids and inquiry estimates may be either a direct or overhead charge depending on circumstances.

. Cost Data

- Return Cost -- This data, when available, is always used when making estimates.

- Previous Bid -- Used only if nothing else is available.

- Vendors Quotes -- Are sought for all items of $10,000 or more, if time is available.

- Literature (Estimating Guides) -- Used very little. Newport News does have a cost estimating manual.

- Shop Estimates -- Are only used occasionally on an as needed basis.

. Technical Data -- Product definition is usually reflected in the RFP. The estimating department is assisted by the engineering departments to determine material quantities and to size equipment. Legal/Contracts is used to flag cost senstivite provisions in Pro Forma Contracts and other procedural documentation or reporting requirements.

(4) Newport News Spends As Much As 50,000 Manhours On An Estimate For A CVN

The estimating procedure at NN follows the normal custom of the industry.

- Degree of Detail

  - For Budget/Idea Pricing the time spent is minimal, from one day to a week, depending upon how real the job is and how familiar the estimator is with the proposed job.

  - The vast majority of time spent by new ship construction estimators is on proposals or bids in response to RFP. The time spent varies from 10,000 manhours on a VLCC to 50,000 on a CVN. The actual submitted estimate for a recent submarine consisted of 3,000 pages of cost summaries and work sheets.

- Material/Labor -- Material and Labor is generally estimated in terms of a four digit SWBS. Material estimates usually reflect quotations for about 50 to 60 percent of total material cost. Steel cost estimates are based on published catalog prices; however, the actual cost is that in effect as of time of delivery. For contracts with escalation, all costs, including steel, are in base month dollars. Where quotes connot be obtained or if stock nature, recent cost history is used as the basis.

- Indirect cost -- Derived from return cost accounts

- Overhead estimates are based on past experience coupled with projections of future work load and future changes to overhead accounts such as payroll fringes, FICA, etc. It is Newport News policy to charge as much expense as possible to specific hulls or projects, so as to minimize indirect charges.

(5) <u>Newport News Is Of The Opinion That Many Recent Legislative, Contractual And Economic Considerations Have Affected The Price Of Ships</u>

This section of the report responds to a number of factors that have been cited as problems by others and the following are the views expressed by Newport News:

- Inflation/Escalation and Form of Contract

  - Newport News is generally of the opinion that escalation adjustments made in accordance with accepted indices would be satisfactory, if 100 percent of overhead was subject to escalation and the escalation covers the entire construction period. At present, new Navy RFP's attempt to provide for more realistic coverage, however, may fall short of this goal especially in the area of overhead. The private VLCC contract made in accordance with MarAd regulations, while providing much needed relief, falls short of adequately covering the contractor for material, labor overhead escalation.

  - The idea was presented that if fringes were included in escalation, the target price could be reduced somewhat.

  - In preparing bids from return costs, BLS indices are used to bring costs to a current base unless it is known that they are inadequate.

- Doing Business With Navy

  - The general discussion on this subject can be summarized by saying that it is "difficult." Most of the problems they believe are "people problems", with particular reference to SEA 08.

- The Navy has adopted a philosophy of participation in contractor's management commonly called "involvement" or "engagement" without accepting corresponding responsibility. In fact, they have formalized this concept and have developed numerous documents explaining this philosophy and instructing their people on its implementation.

- Newport News believes DOD Instruction 7000.2 has some merit. It does establsih a baseline for cost and schedule measurement. How is is implemented by the Navy is the key. Any requirement to force the contractor's system into a rigid mold contrary to how he conducts his business makes it useless. Also, too often Navy loses sight of the fact that it is a reporting mechanism. It does not manage anything -- people do that.

. Doing Business Without Government Involvement

- The discussion was short on this subject. In Newport New's opinion, there is no such thing -- only a matter of degree.

- It was Newport News' opinion that for Navy work it is now a sellers market and for commercial work a buyers market.

. Social Legislation (OSHA, EPA, EEO, Longshoremans and Harbor Worker's Compensation Act)

- The cost of social legislation has not been separately calculated, but it creeps into return costs and is reflected in increased overhead costs and productivity loss.

. Weapon Integration and Testing

- According to Newport News, its responsibility is to install weapons, including electrical hook-up, install black boxes and test each unit by piece and integrate the pieces into systems.

- On the DGN 36 and 37, they believe the problem was that the Navy did not site test Government Furnished Material/Government Furnished Information (GFM/GFI) to iron out bugs between systems and develop software programs that were compatible with the hardware.

- Newport News believes the present split between GFM and Contractor Furnished Material (CFM) to be about right.

. Amortization of Capital Improvements

In paying for new facilities, Newport News has taken several approaches.

- For the large crane in old yard the Navy paid for crane, Newport News paid for rails and supports. Newport News paid the Navy back over 10 years on a double declining depreciation schedule.

- The new commerical yard was a big gamble. The new yard the cost is about 210 million dollars.

. Productivity

- Productivity has been gradually declining, but it is hard to separate general productivity from new requirements.

- Newport News believes the productivity effect of EEO as far as minority males is concerned has leveled out at a point significantly below what it was 10 years ago. Now the emphasis is on women, which is posing problems on the waterfront.

(6) <u>Newport News Considers Many Navy Practices To Be Un-Necessary Cost Drivers</u>

. The recent Navy emphasis on Mil Q quality control requirement where it is not necessary is a cost driver

- The proliferation of referenced Mil Specifications is a cost driver. Example -- GE claims there are 30,000 referenced Mil Specifications associated with construction of a steam turbine.

- A case was mentioned where the bidding specifications for the AS now building at Lockheed referenced Mil Specifications approximately eight years old. The Navy, however, insisted these old specifications be followed for bidding even though manufacturers could only supply equipment to the current specifications. To go back to the old specifications would be more expensive and, in some cases, probably unobtainable.

- Navy does not have a system of identifying specification changes as new issues are distributed. The shipyard must compare the old and the new word by word to find the changes.

XI. IMPACT OF SOCIAL LEGISLATION ON COST ESTIMATING

1. SOCIAL LEGISLATION HAS HAD AN IMPACT ON SHIPBUILIDING COSTS SIGNIFICANTLY DURING THE PAST TEN YEARS

Since 1965 more social legislation has been passed that has had an impact on shipbuilding cost then in the previous thirty years. In the period from 1935 to 1965 the most significant socially-oriented legislation that had an impact on labor cost and productivity were:

- Social Security Act
- Taft Hartley Act
- Workingmen's Compensation Act
- Old Age Benefits FICA
- Unemployment Compensation
- Union Negotiated Benefits
  - Vacation
  - Group Insurance
  - Holiday Pay
  - Pension Fund
  - Thrift Plan
  - Sick Leave
  - Severance Pay
  - Work Rule

All of these social benefits grew gradually and their incremental cost from contract to contract was small and to a large degree predictable. Since 1970, the industry has continued to experience cost growth in these accepted areas, but at a more accelerated rate than in the past due primarily to inflation and a tendency for more liberal judgments. Additional cost, however, has been

placed on top of the normally accepted growth by eight significant legislative acts.

- The Clean Air Act -- Environmental Protection Agency, December, 1970
- Federal Water Pollution Control Act -- June, 1970
- Clean Air Amendments of 1970 -- Public Law 91-604, December 31, 1970
- Noise Control Act of 1972 -- Public Law 92-574, October 27, 1972
- Coastal Zone Management Act of 1972 -- Public Law 92-583, October 27, 1972
- Marine Protection, Research and Sanctuaries Act of 1972 -- Public Law 92-532, October 23, 1972
- Occupational Safety and Health Act of 1970 -- April 28, 1971
- Longshoremen's and Harbor Workers' Compensation Act (LHWCA) Amendments -- Public Law 92-576, November 27, 1972
- EEO Legislation -- various dates

All of these acts have had some impact on the shipbuilding idustry. The ones that feature most prominantly with respect to shipbuilding have been

- Longshoremen's and Harbor Workers' Compensation Act Amendments -- November 1972
- Occupational Safety and Health Act of 1970 -- April 1971
- Various Environmental Protection Acts

2. <u>THE LONGSHOREMEN'S AND HARBOR WORKERS' COMPENSATION ACT NOW APPLIES TO SHIPYARDS AND HAS TRIPLED FROM 1972 TO 1975</u>

According to a Newport News press release of August 3, 1976, their cost for Workingmen's Compensation which is now covered by the act tripled from 1972 to 1975. For 1976, 25 percent more was expected. For 1980, Newport News predicts a bill of $7,000,000 or a 1,600 percent increase in eight years.

(1) <u>In 1973, The Commission On American Shipbuilding Commissioned Todd Shipyards To Make A Study Of The Impact Of Legislation On Shipbuilding Costs</u>

The following are pertinent excerpts from this report.

- Coverage under the Amendments is extended to include any adjoining pier, wharf, dry dock, terminal building-way, marine railway, or other continguous area customarily used in loading, unloading, repairing, or building a vessel. In short, any blue collar worker within the perimeter of the shipyard is subject to the amended law. Before the enactment of the Amendments, on the other hand, only those who were directly engaged in work on the navigable waters of the United States, including dry docks, were covered by the act. Consequently, all other workmen were subject to individual State Compensation Laws.

- Before the enactment of the Amendments, the maximum benefit was $70.00 per week. The Amended Act provides that the maximum compensation for disability shall not exceed 200 percent of the national average weekly wage to be determined annually by the Secretary of Labor. This increase is to 200 percent of the national average weekly wage during the period from October 1, 1975 of $267.00 per week based on the $133.60 national average weekly wage.

- The percentage increases by type of injury are as follows:

-	Fatal	504.4%
-	Permanent Total	469.9%
-	Major Permanent	112.3%
-	Minor Permanent Partial	84.9%
-	Temporary Total	86.1%
-	Medical	No Change
-	Average	130.5%

- The shipyards responding to a survey aimed at determining the additional cost of the increased benefits provided by the Amended Act per $100.00 of payroll indicated that current additional expense would be $4.20 and prospectively $7.22.

- While the ultimate cost of the increase in benefits and the extended coverage to all shipyard employees cannot be determined until the full impact on the industry is established by actual experience, it is abundantly clear that the additional expense will be of the greatest magnitude. The problem is compounded by the fact that shipbuilding contracts are negotiated on a fixed price basis well in advance of commencement of actual construction. Thus, the industry finds itself in the position of paying increased benefits and increased insurance premiums without being able to recover any of this substantial expense under existing contracts.

(2) NAVSEA Cost Analysis Guidance Reflects The Finding Of The Shipbuilders Council Of America

The most recent NAVSEA Cost Analysis Guidance of January 1975 gives the following information:

- Legislative follow-up action by the Select Subcommittee on Labor requested the Shipbuilders Council to survey the industry to determine, among other things, the change in cost of compensation resulting from the amendments and the contributing factors. The Council singled out these areas of major concern:

- Benefits now provided cost more in most yards.

- This uneconomic condition allows actual out-of-pocket compensation costs to exceed real take-home pay. It has the expensive effect of undermining incentive for affected employees to return to work.

- There are a multiplicity of cases alleging hearing losses and other injuries. The resulting administrative and procedural burden on the shipyards is becoming increasingly cumbersome and costly.

. Responses from the 18 shipbuilders representing about 80 percent of the employment in the private sector were examined. Four yards submitted data which could be analyzed, i.e., LHWCA costs in "percent of total payroll". Using weighted averages the added cost of LHWCA is 0.4 percent of the labor rate. It represents an added cost of approximately $0.02 per hour which is not included in overhead rates provided by SEA 0523 or reflected in historical bid rate data.

. When the cost is significant, cost estimates are to separately identify LHWCA added costs in ship cost estimates. These amounts can be determined by applying a factor of 0.004 to the total labor cost estimate.

Example:

When Total Labor is	Added Cost of LHWCA is
$1M	$4,000
$10M	$40,000
$100M	$400,000
$500M	$2,000,000

(3) The Maritime Administration Also Recognizes The Impact Of LHWCA

In a recent analysis of why U.S. shipbuilders cannot compete with foreign shipbuilders, they report as follows:

> "Another rapidly rising cost resulting from federal legislation was the increase in workmen's compensation benefits. In 1973, the Longshoremen's and Harbor Workers' Act significantly upgraded the monetary benefits workers received for claims of work-related accidents. The maximum weekly compensation benefit in 1972 was $70.00. The act provided for the level of benefits to be increased in September of each year from 1973 through 1975. Presently, the maximum compensation is 200 percent of the national weekly wage. The increase is reflected in the insurance premium rate paid by the employer. There has been an indication from shipbuilders that the number of compensation claims has risen substantially. The article, previously referred to in the Baltimore Sun, stated that in 1975 Bethelehem Sparrows Point reported that for every 100 employees, there were 42 cases of injury requiring medical treatment other than first aid. The national average for shipbuilding and repair yards was 22 injuries per 100 employees for that year. Notwithstanding the cost factor, the lost time and manpower that occurs due to injuries has a pronounced impact on productivity rates."

(4) The Overall Impact Of LHWCA is Currently Estimated To Be A Labor Cost Increase Of Three Percent

The research of available documents reveals that the Commission on American Shipbuilding is the most authoritative study done on this subject in February 1973. Their appraisal of the impact on shipyards reads as follows.

"The shipyards responding to a survey aimed at determining the additional cost of the increased benefits provided by the Amended Act per $100.00 of payroll indicated that current additional expense would be $4.20 and prospectively $7.22. Relating these costs to the base labor rate of $4.41 per hour as developed by the Bureau of Labor Statistics for shipbuilding and ship repair work as of September 1972, the current increase in the hourly billing rate would be $.185 and prospectively $.318. Assuming an hourly billing rate of $10.00, the percentage increases would be 1.85 percent and 3.18 percent."

The most recent estimates from the Shipbuilders Council of America is now averaging 3.56 percent.

The president of Lockheed Shipbuilding and Construction Company, recently emphasized rising rates of insurance coverage. He stated:

"While the changes to the Longshoremen's and Harbor Workers' Act were made in 1972, the full thrust of those changes was not felt until March 1976. At that time, our insurance carrier informed us, through our broker, that the renewal rate for (Longshore Act) coverage was in increase 227 percent for the April 1, 1976/April 1, 1977 policy year. This increase from rate of $11 to $25 per $100 of payroll represented a $4:5 million increase in premium for the shipyard."

(5) The Coordinator Of The Shipbuilding Conversion And Repair DOD Reports The LHWCA Impact On Workers Compensation Insurance

According to the Coordinator's "Annual Report On The Status Of The Shipbuilding And Ship Repair Industry Of The United States 1976" alleged hearing cases have driven insurance rates skyward.

- The broadening of the Longshoremen's and Harbor Worker's Compensation Act has affected shipyards' ability to obtain workers' compensation insurance and has increased the cost of such coverage. The naval shipyards were similarly affected by a liberalized

Federal Employees' Compensation Act in 1972. Hearing loss claims, in particular, have risen to astonishing levels in the past six years. Since 1973, a total of $50.8 million has been paid for hearing loss in active naval shipyards. A $150 million total payout can be predicted for naval shipyards. This amount does not include Army, Air Force, or any of the Navy's other activities.

- The Navy has apprised Congress of problems with the Department of Labor's Office of Workers' Compensation Programs (OWCP) administration of the laws and of employee abuse of compensation rights and the resultant costs. The Government Accounting Office (GAO) has recommended changes OWCP policies.

- Efforts will continue to ensure that workers are adequately compensated for legitimate hearing losses and those workers still employed are provided protection to prevent hearing loss. The success of these efforts rests with strict enforcement of the provisions of the law, including adequate investigation of all claims and suitable penalties for those who knowingly present fraudulent claims.

(6) <u>It Is Feared That The Liberalized Federal Employees Compensation Act of 1972 Provisions May Carry Over To LHWCA</u>

Both LHWCA and the Federal Employees Compensation Act 1972 (FECA) are administered by the Department of Labor and the judgments for awards are made by the Office of Workingmens Compensation (OWCP). At the present time the awards made under FECA exceed LHWCA by a ratio of 7 to 2.5.

The growth in Department of the Navy (DON) workingmen's compensation has grown from 1.8 million dollars to 82.9 million in

1976, shown on Table D.17. Its private industries fear that this will eventually carry over into the private sector.

One of the most significant concerns of the Navy are hearing loss claims in Naval Shipyards. Since 1969 they have paid out approximately $72 million. The potential liability is believed at this point to be about $150 million. Table D.18 shows the record through 1976. Another major cost is "Continuation of Pay" (COP) which allows 45 days with pay while claim is being processed. It is growing, and could become a major expense.

The most significant potential financial disaster that may be forth coming are judgments for asbestosis. According to the Navy these claims could run into millions of dollars.

3. THE OCCUPATIONAL SAFETY AND HEALTH ACT (OSHA) OF 1970 IS ONE OF THE NATIONS MOST IMPORTANT LEGISLATION

The Occupational Safety and Health Act of 1970 went into effect on April 28, 1971. It is one of the most important legislation ever passed by the Congress of the United States. The Act established the Occupational Safety and Health Administration, within the Labor Department.

OSHA is empowered to set safety and health standards for just about every non-governmental employer; the only exceptions are employers and

TABLE D.17

DEPARTMENT OF NAVY WORKMEN'S COMPENSATION COSTS
(Dollars in Millions)

Year		Year	
1962	$ 1.8	1970	$14.6
1963	3.1	1971	21.0
1964	4.4	1972	30.3
1965	5.8	1973	30.1
1966	6.6	1974	40.3
1967	7.6	1975	60.8
1968	8.2	1976	82.9
1969	11.1		

TABLE D.18

RECENT DEVELOPMENTS-HEARING LOSS CLAIMS STATISTICS-ACTIVE NAVAL SHIPYARDS

CY	#Incoming Claims	# Paid Claims	Amt. Paid ($ Millions)
1969-1972	4,834	1,361	$10.4
1973	3,370	573	4.7
1974	3,528	1,136	9.9
1975	3,709	2,512	17.1
1976 (9 mos.)	3,113	3,016	19.0
	18,554	8,598	$61.2 (1)
By Yard			
Portsmouth	1,073	271	$ 2.1
Philadelphia	4,677	1,841	12.2
Norfolk	4,623	2,457	17.6
Charleston	836	276	2.2
Long Beach	3,472	1,180	8.9
Mare Island	3,193	2,019	14.0
Puget Sound	633	522	3.7
Pearl Harbor	37	32	0.4
	18,554	8,598	$61.2

(1) 12 month of 1976 brings total value to about 72 million dollars

businesses operated solely by members of a family.

(1) OSHA Has Included In Its Safety Regulation Many Standards Developed By Other Legislation And Industry Associations

Prior to the passage of the Occupational Safety and Health Act of 1970, employers in the shipbuilding industry were responsible for compliance with Part 1502 of the Safety and Health Regulations for Shipbuilding, under the Longshoremen's and Harbor Workers' Compensation Act of 1927.

Part 1502 of the Safety and Health Regulations for Shipbuilding requires every employer to furnish and maintain employment and places of employment which are reasonably safe for his employees and contain specific regulations and standards regarding:

- Dangerous Atmospheres
- Surface Preparation and Preservation
- Welding, Cutting and Heating
- Scaffolds and Ladders
- Working Surfaces
- Material Handling Equipment
- Tools and Related Equipment
- Personal Protective Equipment
- Ship's Machinery and Piping Systems
- Portable, Unfired Pressure Vessels
- Electrical Equipment

In addition, under the authority vested in the Secretary of Labor, certain specifications, standards and codes of the following

organizations were included in Part 1502 of the Safety and Health Regulations for Shipbuilding:

- National Fire Protective Association
- Underwriters Laboratories, Inc.
- American Society of Mechanical Engineers
- American Conference of Governmental Industrial Hygienists
- American Standards Institute

(2) The Impact Of OSHA On The Shipbuilding Industry Is On A Par With Industry In General

An early survey in September 1972 by the National Association of Manufacturers indicate the initial impact to comply with the then known OSHA requirements to be of the following order of magnitude.

Company Size (Number of Employees)	Estimated Expense (Weighted Average)
1 - 100	$ 33,000
101 - 500	104,000
501 - 1000	212,000
1001 - 2000	372,000
2001 - 5000	863,000
Over - 5000	7,146,000

The impact of OSHA on the shipbuilding industry is not unlike industry in general, shipbuilders' compliance costs to date have been for the purchase of protective equipment coupled with the replacement of tools, ladders, scaffolding and machinery/equipment components which do not meet the OSHA Standards. In shipbuilding three areas are affected most; Tool Standards, Noise Standards and House-

keeping.

- An example of tool standard expense was the modification of hand chipping hammers. The reported cost to one shipyard was $295,000 and over 50 percent loss in productivity.

- The OSHA noise regulations are brief, but far-reaching. Basically, there are two sections: the first sets the maximum levels of industrial noise to which an employee may be exposed; the second section explains what action the employer must take if these levels are exceeded.

- In cases where the sound intensity exceeds the levels in the standard, the law is explicit about what must be done.

These regulations are particularly difficult for the shipbuilding industry to meet because unlike most industries where noise levels are fairly constant, shipyard work and particularly that aboard ship generates a wide variation of noise levels at many different locations. Operations involving the utilization of impact tools, grinders and ventilating equipment in confined spaces are principal contributors to such noise variations, which at time exceed the permissible limits. While tool and equipment manufacturers have been made aware of these problems, it has not been possible to reduce the sound intensity to meet the Standards and still maintain reasonable productivity.

Efforts to reduce the noise level of impact tools such as scalers and hammers have met with little success, however, hearing protective

equipment is furnished to shipyard employees with specific instruction for its use. Because of the variable and intermittent noise levels encountered in ship work, coupled with the discomfort claimed by many employees when wearing ear plugs, it has been found most difficult to have all personnel adhere to the OSHA requirements. Nevertheless, the shipyard is responsible and liable to citations and fines for failure of some employees to wear the equipment furnished.

Hearing protection and policing is expected to be the greatest economical impact of the OSHA Noise Standards. However, the legal and compensation costs connected with questionable hearing loss claims may be posing an even greater problem. One shipyard, reported a total of 77 hearing loss claims during calendar year 1972. Of this amount, 41 claims have been settled at a cost of $85,729.000. The 36 claims pending settlement are conservatively estimated to cost $86,266.00 making a total of $171,995.00.

General "housekeeping" is particularly difficult in the opinion on the shipbuilding industry. This study prepared by the Commission on American Shipbuilding (February 1973) read as follows.

> "The Shipbuilders Council of America, in a concerted effort to apprise its members of what is expected of them under OSHA, initiated a Safety and Health Citation Exchange in January 1972. During the past year, participating members of the Council reported 463 citations for alleged non-conformance to

the OSHA Standards. Out of this total, 98 citations or 21 percent were issued for poor housekeeping. The vast majority of these citations, which by far exceed in number those issued for any violation, were issued because hose, cable and materials were found on the deck or in passageways by the inspector.

While shipyard administrators, supervisors and safety engineers are cognizant of the hazards resulting from careless housekeeping, it has been found that the additional supervision and labor engaged in efforts to comply with OSHA and the resultant delays and work stoppages continue to be extremely costly.

A West Coast shipyard initiated and completed three identical conversion jobs during 1972. Services most directly affected by the OSHA Standards were in the areas of housekeeping, lighting and ventilation, and staging. Estimates for these services were based on past performance cost returns on similar conversions.

Actual costs for housekeeping under OSHA exceeded the original estimates by percentages of 192, 188 and 204. Similarly, the actual costs for lighting and ventilation were 160, 170 and 192 percent greater than the estimates and the staging estimates were overrun by percentages of 100, 91 and 100.

The costs for additional safety and supervisory personnel assigned to these conversions, in an effort to comply with OSHA, are not included in these figures. Nevertheless, the shipyard has been further burdened by many costly citations and resultant legal fees for appeals in cases where the alleged violations reached the point of absurdity."

(3) OSHA Requirements Have Become A Concern To The Navy And The Maritime Administration

The Navy has reviewed the eight Naval Shipyards and estimated that 239.3 million dollars would be needed to meet their interpretation of current OSHA regulations as follows:

	Million $
Portsmouth	11.8
Philadelphia	82.4
Norfolk	54.4
Charleston	39.4
Long Beach	6.1
Mare Island	23.0
Puget Sound	17.7
Pearl Harbor	4.5
	239.3

These have been broken down in hazard categories as follows:

	Million $
Serious	61.9
Non-Serious	173.2
Minimal	4.2
	239.3

Concern has been expressed as to the ultimate impact of OSHA requirements which presently, for 65,000 Naval Shipyard employees, amounts to over $3,500 per employee.

Currently the Maritime Administration and Navy are jointly funding a detailed study by Safety Sciences (May 1977) of OSHA Standards as they apply to the Shipbuilding and Repair (SB/SR) Industry. The Long Beach Navy Shipyard will act as Project Manager. The general scope of this study is as follows:

- Approximately two years will be required to achieve the following major OSHA Project objectives.

- Identify and document SB/SR industrial operations
- Identify and document OSHA standards applicable to the SB/SR industry
- Develop proposed standards where voids in needed coverage exist
- Determine financial impact of implementing standards which are not generally implemented within the industry
- Determine probable safety and health benefits of implementing standards which are not generally implemented within the industry
- Draft proposed alternative OSHA standards for those determined technically or economically infeasible of implementation, relative to benefits expected of the original OSHA standards
- Prepare the following fully coordinated SB/SR industry documents to be formally proposed by the industry advisory panel to the Department of Labor for adoption

    a. Manual of SB/SR OSHA standards,

    b. Management guide for effective implementation of the SB/SR OSHA Manual; to include internal audit, documentation, analysis and implementing guidelines.

4. <u>ENVIRONMENTAL LEGISLATION HAS HAD A SIGNIFICANT IMPACT ON THE SHIPBUILDING INDUSTRY</u>

No assessment of the United States shipbuilding industry would be complete or conclusive without putting into perspective the economic impacts of pollution abatement requirements on the shipbuilding industry's activities.

The physical shipyard plant is an integrated industrial complex and waterfront facility and unique in that they are subject to the overlapping authority and actions of agencies within the Federal, State and local governments with respect to pollution abatement and environmental concerns.

(1) 34 Shipbuilding Installations Surveyed In 1972 Estimated That Environmental Requirements Add 20 Percent To The Cost Of New Facilities

A survey made for the Commission on American Shipbuilding of some 34 installations showed the following range of expective cost increases:

		Low	High	Average
Overhead - Estimate Percentage of Change				
Industry	Current	+.2%	+50%	+4.2
	Prospective	+.3%	+53%	+7.1
Hourly Production Cost - Est. Percentage of Change				
Industry	Current	-2%	+28%	+3.2%
	Prospective	-7%	+30%	+5.4%
Hourly Billing Rate - Est. Assigned Cost ($)				
Industry	Current	+.01	+1.38	+.19
	Prospective	+.01	+1.72	+.54

Facilities Improvement - Est. Additional Cost Expended (%)			
Industry	0%	100%	20%
Specific Maintenance - Est. Additional Cost Incurred (%)			
Industry	0%	75%	12.6%
Additional Man-Days Expended for Environmental Matters			
Industry	-0-	6525	1378

Data shown represents inputs of what 34 installations are or will experience economically and operationally for environmental considerations. The facilities owned and operated by the responders represent 79 percent of the major shipyards in the United States. The current and projected increases in overhead, hourly production cost, hourly billing rates are significant and definitely will impact the future competitive viability of the industry.

5. SINCE 1969 MINORITY EMPLOYMENT HAS INCREASED BY 62.5 PERCENT AS COMPARED TO 1.3 PERCENT FOR OTHERS

In addition, EEO legislation which has promoted the employment and advancement of minorities, women and the handicapped has been felt in some shipyards in terms of productivity loss due to needed training and a certain lowering of morale among experienced non-minorities because of real or imag-

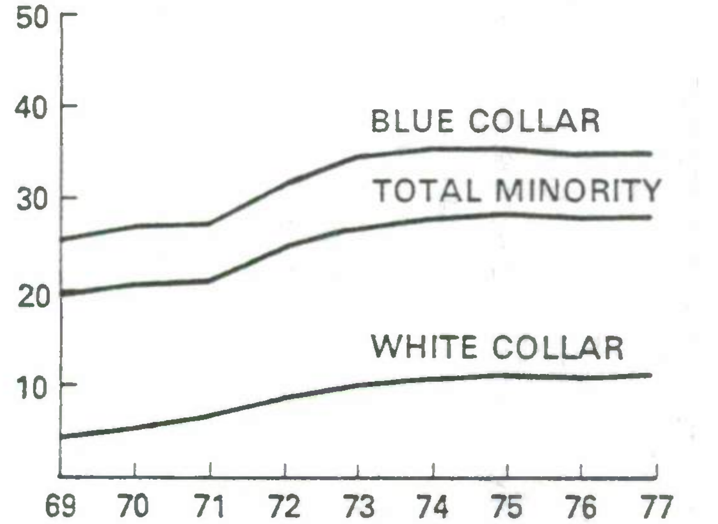
inary loss of expected advancement opportunities or simple prejudice. To our knowledge, no effort to quantify this effect has been released from the various shipyards.

An analysis of the records of the Office of Civil Rights, U.S. Maritime Commission shows that advances that have been made in promoting minority employment in the shipbuilding industry. Since 1969, employment has grown about 13 percent, representing 14,965 jobs. Of this growth, 13,703 went to minorities and 1,266 went to non-minorities. This represents a 62.5 percent increase in minority employment and 1.3 percent growth for non-minorities.

The growth of minority employment as a percent of total employment is shown on Figure D.44. Minorities now occupy 28.1 percent of the jobs as of 1/77 compared to 19.6 percent in 1969. Figure D.45 shows the percentage increase of minority employment in various categories. This shows a great increase in white collar employment (over 160 percent) and a shift in the blue collar ranks from un-skilled and semi-skilled to skilled categories. Skilled crafts such as welders, shipfitters, machinists, etc. has increased 77 percent.

FIGURE D.44

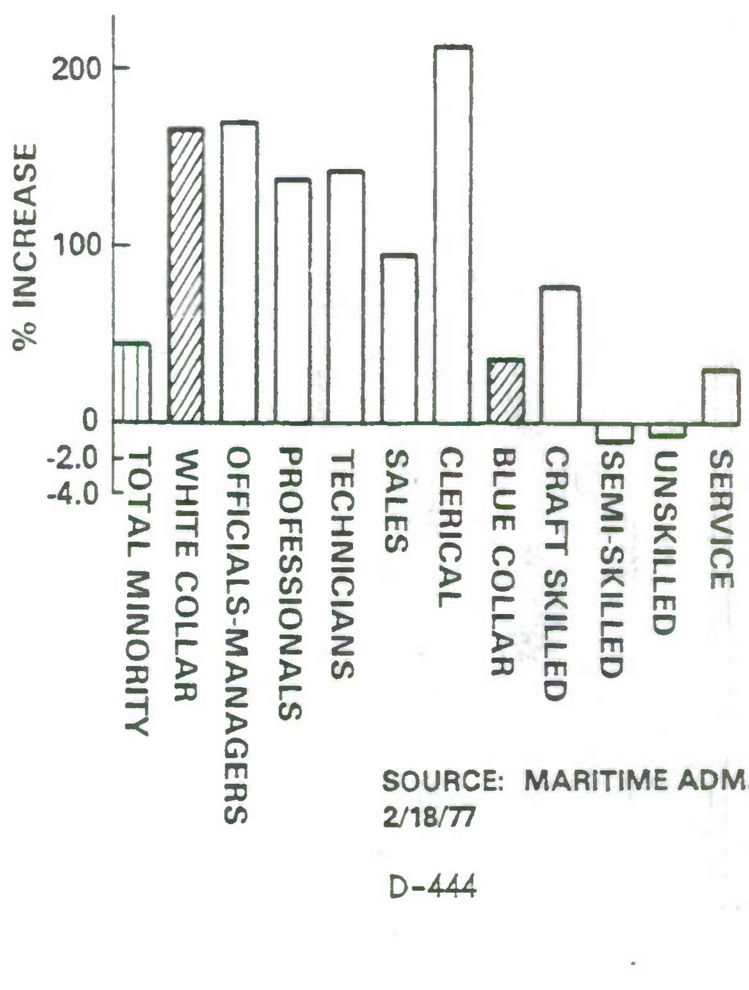
MINORITY EMPLOYMENT CHANGE AS A % OF TOTAL WORK FORCE IN SHIPBUILDING



SOURCE: MARITIME ADM. 2/18/77

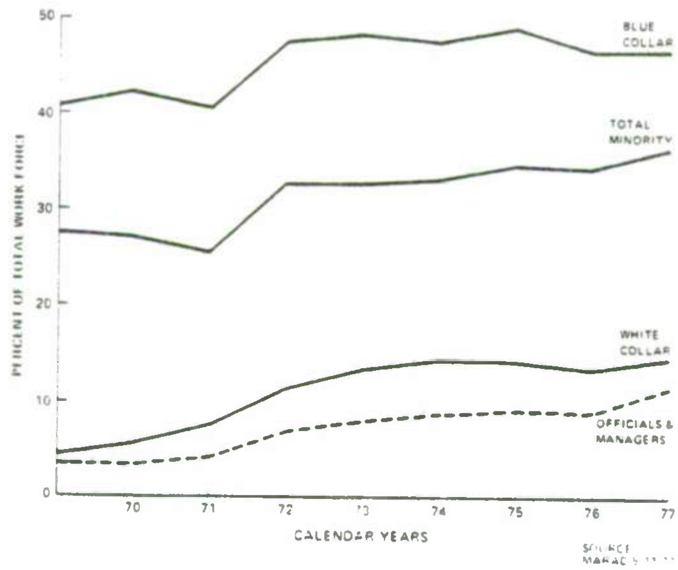
FIGURE D.45

MINORITY GROWTH IN % FROM 1969 TO 1977



SOURCE: MARITIME ADM. 2/18/77

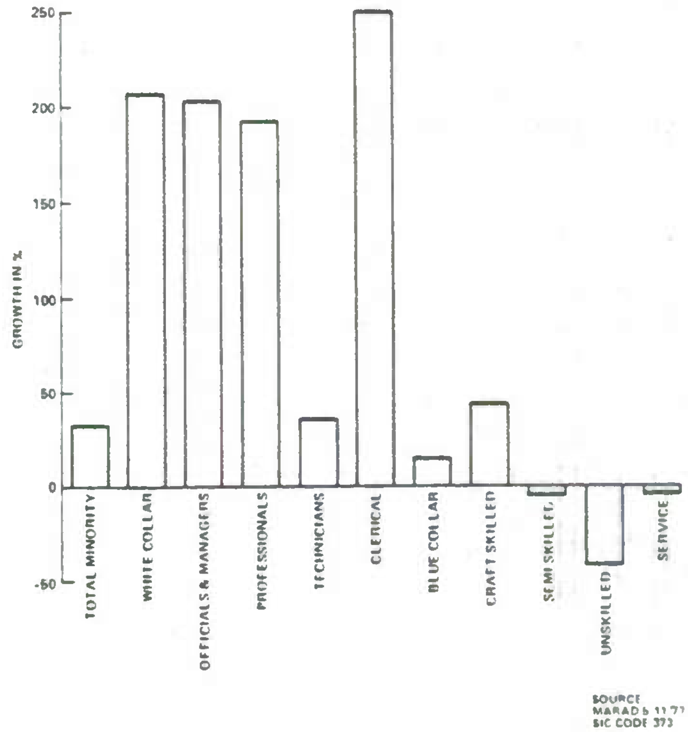
FIGURE D.46
MINORITY EMPLOYMENT CHANGE AS A % OF TOTAL WORK FORCE AT NEWPORT NEWS



The growth of minority employment, at Newport News for example, as a percent of total employment is shown on Figure D.46. Minorities now occupy 36.2 percent of all jobs as of January 1977 compared to 27.5 percent in 1969. Figure D.47 illustrates the percentage increase of minority employment in various categories and emphasizes the trend to white collar employment and a shift in the blue collar trades from unskilled and semi-skilled to skilled categories. The increase in skilled crafts such as welders, shipfitters, machinists, etc., has been 43.3 percent.

FIGURE D.47

MINORITY EMPLOYMENT GROWTH
IN % FROM 1969 TO 1977
NEWPORT NEWS



(1) <u>The Overall Impact Of Social Legislation During The Last Ten Years Is Believed To Be Substantial</u>

A review of published data on impact of social legislation upon shipyards indicates that no recent overall evaluation has been made. The study on this subject made for the Commission on American Shipbuilding in 1973 remains the latest overall analysis on the subject.

The shipyards visited during the course of this study point to a substantial increase in overhead costs and decline in productivity as reflecting the long term price being paid for these social improvements.

Today one of the most onerous of these legislative acts is the rising cost of working mens compensation under LHWCA on the one hand and EEO legislation requiring the hiring of the handicapped who are considered high risk employees on the other.

Another enigma is the urging of the shipyards by Navy and MarAd on the other hand to improve facilities, new piers, ways docks etc., and the resistance to those improvements by Federal, State and local environmental laws and procedures. The high price of technical, administrative and legal funds involved on both sides of these issues increase the cost to the shipyard and the procurement. In the end it is all paid for by the taxpayers.

EXHIBIT D.1

SHIPYARD OVERHEAD STUDY

Prepared for

INTERNATIONAL MARITIME ASSOCIATES, INC.
as part of
Study to Review Cost Estimating Functions
in the Naval Sea Systems Command

Contract No. N00024-77-C-2013

Prepared by

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February 18, 1977

INDEX

I. Introduction and Scope

This study of shipyard overhead and overhead cost drivers forms part of the detailed review of Navy's cost estimating procedures and the elements that make up their estimates of costs which is being performed for the Navy under Contract No. N00024-77-C-2013 by International Maritime Associates, Inc.

Particular concern has been expressed relative to the fact that over the past ten years overheads in the shipbuilding industry have risen from a range of 60 to 80% of Direct Labor $s to a range of 90-120% of Direct Labor $s.

This study therefore concentrated on the following areas:

- Identification of factors that have driven overhead rates up over the past several years and analysis of the effect of each major overhead cost drivers.
- An analysis of the possible courses overhead cost drivers could take in the next 5 years and the effect on overhead rates.
- A brief analysis of the increases in overhead charged to a ship due to extended building periods.
- Verification of current state of the art with respect to overhead estimating and forecasting and based thereon the consideration of how the Navy Estimating procedures may most adequately project the shipyard overhead on ships contracted for and constructed over a period of several years after the original estimate was prepared.

2. Analysis of Overall Shipbuilding Cost Factors

In order to obtain perspective with respect to the growth in overhead referred to in the introduction we studied actual costs incurred on six different ship contracts covering 14 ships with an aggregate target cost value of more than $1.3 billion. These ships were built in one yard in the time period 1967 to 1977. The target cost figures were adjusted for change orders and esculation before comparisons with actual were made. The results are summarized in the following tabulation:

	Composition of adjusted target cost %	Composition of actual cost (Target cost = 100)	Growth of actual over target cost %	Composition of actual cost %
Labor	39	60	53	40
Material	38	40	5	30
Overhead	23	40	74	30
Total cost	100	140	40	100

The 74% growth in overhead $'s is indeed startling in relation to the 53% growth in labor $'s and confirms the desirability of further analysis of overhead cost "drivers".

For further perspective it is to be noted that labor hours grew by only 19%, construction span time (start of construction to delivery) grew by 44% but change order hours (Navy estimate) grew by only 5.5%.

3. Analysis of Overhead Cost Elements & Identification of Cost Drivers

During the period in question, the shipyard's targeted manning was never achieved, as reflected in the growth in construction span time, and the ratio of indirect to direct employees was subject to significant fluctuations - for reasons which are outside the scope of this study.

3. Analysis of Overhead Cost Elements & Identification of Cost Drivers (continued)

To permit comparison of year to year costs without the "background noise" of varying manning levels the absorption of fixed and other overhead charges was made based upon the employment of 16,300 equivalent direct employees at 40 hours per week and 3,500 indirect personnel during the period 1969 - 1975.

For analysis purposes it appeared reasonable to group the various individual elements into nine categories of overhead falling into three major catagories as follows:

- Human Related "Variable" Costs
- "Semi-Variable" Costs
- "Fixed" Costs

The overhead composition is described in more detail in Table I. It should be emphasized that these groupings shown in Table I, while adequate for this study are not based on in-depth analysis, are not recommended as such, and they will in practice vary between shipyards, based on their individual accounting practices.

Correction of the historical data for level employment revealed the comparative costs per direct labor employee by element of overhead as shown in Table II.

Table II shows that the 1969 - 75 compound rate of growth for labor $s was 6.3% per year. Overhead as a whole grew at a compound rate of 11.8% per year, the growth rate for its major elements being:

- Human Related "Variable" Costs - 11.53%
- "Semi-Variable" Costs 23.40%
- "Fixed" Costs 6.5 %

As might be expected the chief driver, because of the $'s involved, in the <u>human related costs</u> was fringes and benefits at 13.4%, although maintenance, bid and proposal, IR&D grew at a 21.8% rate.

TABLE I

OVERHEAD COMPOSITION

Elements	Composition	Variability
Human Related "Variable" Costs		
• Indirect Labor	Supervisory, Clerical and Misc. Personnel	Variable with D.L.
• Maintenance Labor, Bid & Proposal Expense & IR&D	Maintence of building, tools, calibration of tools, independent research & development, & proposal expense	Variable with D.L.
• Fringes & Benefits	Allowed vacations, holidays, workmen's compensation, disability, pensions	Variable with D.L. & I.L.
"Semi-Variable" Costs		
• Maintenance & repair material	Maintenance & repair material, acquisition of consumable tools	Partly variable with D. L.
• Energy Costs	Electricity, coke, fuel oil, coal, gas	Partly variable with D.L.
• Information processing/home office expense	Inter-company fees, home office expense, computer service charges	Partly variable with D.L.
"Fixed" Costs		
• Depreciation & Others	Taxes, depreciation & insurance	Fixed
• Fixed repairs	Assumed to be subcontracts & materials for major maintenance & subject to capitalization	Fixed
• General overhead	Water, sewage, supplies, rentals, accounting & legal expense, misc. material, service charges, material & subcontracts for bid & proposal & IR&D, advertising, inventory adjustments, stores expense, interest expense, state taxes.	Primarily Fixed

3. Analysis of Overhead Cost Elements & Identification of Cost Drivers (continued)

The chief driver under semi-variable costs was home office charges and information processing at 66%, with energy costs being second at 21.4%.

Table II also includes the writer's "guesstimate" as to the possible rate of growth by category for each of the nine elements of overhead as well as of direct labor and the resultant projected 1980 costs per employee.

It will be noted that the overhead as a % of direct labor grew from 60.5% in 1969 to 81.9% in 1975 but in 1980 it could be back to 76%.

The total labor and overhead $ cost to the U.S. Navy per direct labor employee went from approximately $13,000 in 1969 to $21,000 in 1975 and could reach $32,000 in 1980. The 1969 - 75 compound growth rate of 8.5% compares with the BLX-CPI rate (1967 = 100) of 6.47%.

In order to further understand the cost drivers, Table III was prepared This shows each of the elements as a component of the total overhead rates of 60.5% in 1969 and 81.9% in 1975 The increase or (decrease) during the period and the percentage contribution to the overhead rates is shown. We have also estimated the approximate degree to which each of the elements is:

- Fixed by previous decisions
- Shipyard controllable
- Home office controllable

or
- Driven by external pressures.

It is significant that human related overhead contributed 71.5% of the overhead growth rate. Within that category 52.3% constituted fringes and benefits which in our opinion were 80-90% driven by external pressures. A breakdown of fringes and benefits by its elements and their growth over a six year period ending in 1975 is shown in Table IV. During that time they more than doubled.

TABLE II

STEADY STATE MODEL

AN EAST COAST SHIPYARD

Comparative Actual Costs Per Direct Labor Employee ($s) by Element of Overhead

Assumptions:

- Constant Work Load
- 16,300 Equiv. Direct Labor Employees @ 40 hours
- 3,500 Equiv. Indirect Employees @ 40 hours
- Ratio $\frac{\text{Indirect}}{\text{Direct}}$ - 21.5

	1969	1970	1971	1972	1973	1974	1975	Historical Compound Rate of Growth	Guesstimate: Projected Compound Rate of Growth	Guesstimate: Projected 1980 Costs
Annual Pay/Direct Labor, Employee	$ 8,150	$ 8,636	$ 8,910	$ 8,971	$ 9,508	$10,340	$11,761	6.3 %	9 %	$18,095
Overhead										
Human Related "Variable" Costs										
• Indirect Labor	1,526	1,543	1,715	1,559	1,566	1,987	2,176	6.9	6	2,912
• Maintenance labor, bid & proposal expense & RD&D	272	306	258	432	541	636	889	21.88	10	1,432
• Fringes and benefits	1,921	2,525	2,530	2,609	2,936	3,575	4,091	13.43	6	5,475
Subtotal	3,719	4,374	4,603	4,600	5,043	6,198	7,156	11.53	6.53	9,819
"Semi-Variable" Costs										
• Maintenance & repair material	155	167	232	291	203	162	198	22.0	5	253
• Energy costs	161	219	223	203	221	455	516	21.42	10	831
• Information processing/Home office expense	23	31	31	260	320	574	483	66	10	778
Subtotal	339	417	486	754	744	1,191	1,197	23.40	9.24	1,862
"Fixed" Costs										
• Depreciation and others	345	400	461	503	420	338	384	1.9	2	424
• Fixed repairs	100	102	102	156	151	166	186	11.0	6	249
• General overhead	429	459	579	955	782	287	710	8.76	10	
Subtotal	874	961	1,142	1,614	1,353	791	1,280	6.57	9.27	1,994
Total overhead per DL employee	$ 4,943	$ 5,752	$ 6,231	$ 6,968	$ 7,140	$ 8,180	$ 9,633	11.80%	7.20%	$13,675
Overhead % to DL	60.5%	66.6%	69.9%	69.9%	75%	79.1%	81.9%			76%
Total L&OH $ to U.S. Navy/Direct Labor employee	$13,082						$21,394	8.54%	8.23%	$31,770
[illegible] - CPI (1967 - 100)	107-113	113-119	11[illegible]23	123-127	128-139	140-155	156-166	6.47%		

TABLE III

ANALYSIS OF OVERHEAD COST DRIVERS

MOVEMENT OF OVERHEAD ELEMENTS AS A % OF DIRECT LABOR $'S

1969 to 1975

					Percentage of elements controlled by				
	1969	1975	Increase 69-75	% contribution to overhead rate growth	Previous shipyard decisions	Shipyard controllable	Home office controllable	Driven by external measures	Overhead points controllable by shipyard
Direct labor	100	100							
Overhead Elements									
Human Related Variable Costs									
• Indirect labor	18.7	18.5	(.2)	(.9)		90		10	16.7
• Maint., B&P & IR&D	3.3	7.6	4.3	20.1		90		10	6.8
• Fringes and benefits	23.6	34.8	11.2	52.3		10 - 20		80 - 90	5.2
Subtotal	45.6	60.8	15.2	71.0					28.7
Semi-Variable Costs									
• Maintenance and repair material	1.9	1.7	(.2)	(.9)		90		10	1.5
• Energy costs	2.0	4.4	2.4	11.2		25		75	1.1
• Information processing/ home office	0.3	4.1	3.8	17.8		25	75		1.0
Subtotal	4.2	10.2	6.0	28.0					
Fixed Costs									
• Depreciation and other	4.1	3.3	(.9)	(4.2)	75			25	
• Fixed repairs	1.2	1.6	.4	1.9	100				
• General overhead	5.2	6.1	.9	4.2	33	33		33	2.0
Subtotal	10.7	10.9	.2	1.0					
Total overhead rate (% DL)	60.5%	81.9%	21.4%	100					34.3

Note: Totals do not add exactly due to rounding.

TABLE IV

Analysis of Fringes and Benefits
(Adjusted for Constant Workload)

	Increase in yearly payments 1969-1975 ($millions)	% of total increase	% driven by external cost pressures
Changes in Benefits Mandated by Law			
Old Age Benefits FICA	7.2	18.41	100
Workmen's Compensation	1.4	3.58	80
Unemployment Compensation	.2	.51	100
Subtotal	8.8	22.5	
Other Benefits			
Vacation	8.7	22.25	75
Group Insurance	9.0	23.01	80
Holiday	4.6	11.76	100
Pension Fund	4.8	12.28	100
Thrift Plan	3.5	8.95	80
Disability	.1	.25	
Allowed Time	.3	.76	
Sick Leave	(.7)	(1.79)	
Severance Pay	-	-	
Subtotal	30.3	77.5	
Total 1969-1975 Increase	39.1	100	80-90

Note: Total adjusted fringe package - 1975 approximately $67 Million.

3. Analysis of Overhead Cost Elements & Identification of Cost Drivers (continued)

This probably represents a "catch" in this area and as noted in our guesstimate for the next 5 years (Table II), we would expect the compound rate of growth for fringes to drop to 6% from the 13.4 rate in the period 1969 - 1976, whereas we would expect the rate of growth of direct labor $s/employee to rise to 10%.

Energy costs, water sewage are all opportunity areas for cost savings by efficiency and conservation. Increases in bid and proposal and I.R.&D while reimbursable under ASPR certainly represent areas for constructive audit as would the subject of home office charges.

While the %'s shown by element of overhead cost and overall overhead %'s as traditionally applied in Navy cost estimating and budgeting are useful as an end product, it is obvious that no meaningful analysis of overhead at any level can be made unless specific costs are considered. Such analysis of the discrete costs is now only performed by DCAA and their audit does not necessarily establish with NAVSEA management the full potential for cost savings.

The changing % composition of the overhead by its elements during the years 1969 - 75 and as "guessed" for 1980 are shown in Table V which may give further emphasis as to the need for analysis of discrete numbers mentioned above.

TABLE V

STEADY STATE MODEL

COMPOSITION OF OVERHEAD (%)

	1969	1975	1980 Guesstimate
Human Related "Variables"			
• Indirect labor	30.9	22.5	21.3
• Indirect Repair & IR&D & Bid & Proposal, Tools	5.5	9.2	10.5
• Fringes & Benefits	38.9	42.5	40.0
Subtotal	75.4	74.2	71.8
"Semi-Variable" Costs			
• Maintenance & repair material	3.1	2.0	1.9
• Energy costs	3.3	5.4	6.0
• Information processing/home office expense	.5	5.0	5.7
Subtotal	6.9	12.4	13.6
"Fixed" Costs			
• Depreciation & Others	7.0	4.0	3.1
• Fixed Repairs	2.0	1.9	1.8
• General Overhead	8.7	7.5	9.7
Subtotal	17.7	13.4	14.6
Total	100%	100%	100%

4. Effect of Delay on Overhead Rate

Because naval shipbuilding programs in the last decade have been subject to delay or expansion of the construction span time it was requested that this study include some discussion of the effect of delay on the overhead rate.

Assuming a stable workload, any delay in construction will almost certainly increase the overhead rate and therefore the project cost. To illustrate this effect we have prepared a hypothetical example, shown in Table VI. For simplicity we have assumed that the project represents 100% of the yard's capacity, that the actual construction time stretch is twice the schedule of two years and that it is due to external forces. We have shown the budget and three separate cases:

Case 1. A well managed stretch out
Case 2. A questionably managed stretch out
Case 3. Case 2 adjusted for 10% esculation

In the well managed stretch out, prompt and effective management response to the external force maintains the labor efficiency and reduces variable overhead in timely manner. The result is that the overhead rate increases by 20 points (from 80 to 100% of direct labor $s) and the "price" to the Navy increases by 6.5%.

In case 2, there is a 10% drop in labor efficiency due to slow management reaction and "variable" overhead is not curtailed. The overhead increases by 65 points to 145% and the "price" to the Navy by 29%. With 10% esculation added, the price increases by 55%.

The effect of delay on overhead cost is therefore significant even where labor costs are kept under control. Since the promptness and effectiveness of management response to delay factors is at best difficult to judge and with the preponderance of current contracts being cost type or incentive contracts including esculation factors and as long as the government pays claims for overruns of budget overheads

4. Effect of Delay on Overhead Rate

it would appear to be vital that personnel of the highest quality and training in the complexities of shipbuilding and shipyard management be assigned to monitor and constructively influence contractor performances.

TABLE VI

EFFECT OF DELAY ON OVERHEAD RATE

$ (millions)

		Budget		Example 1 "Well managed" stretchout		Example 2 "Questionably managed" stretchout		Example 3 Example 2 adjusted for 10% escalation
Material		50		50		50		61
Direct Labor		50		50		55		67
Overhead:								
Variable	30		30		60		73	
Fixed	10	40	20	50	20	80	24	97
Total Cost		140		150		185		225
Fixed Fee		14		14		14		14
Price to US Navy		154		164		199		239
Overhead Rate		80%		100%		145%		145%

Assumptions:
This project is 100% of yard capacity.
Time stretchouts assumed to be to twice the schedule (schedule = 2 years).

Example 1:
Stretchout due to external forces, no increase in material or Direct Labor. Prompt management response to stretchout preserves Direct Labor efficiency and reduces variable overhead in a timely manner.

Example 2:
Stretchout due to external forces, no increase in material, Direct Labor efficiency drops by 10% due to slow management reaction to stretchout; overhead not curtailed during stretchout.

5. Ship Cost Estimating in NAVSEA

5.1 Current State of the Art - Overhead Estimating and Forecasting

5.1.1 Budget Estimates

01G provides an estimate in the form of an average or "most reasonable" overhead % to direct labor based on

- past overhead rates bid on both Navy and MARAD in the yard or yards most likely to receive the work in question,
- judgments solicited from various sources as to projected work load as compared to the past
- a resultant "guesstimate" as to the future labor rate.

Recent attempts have been made to obtain and use overhead audit reports (as developed by DCAA Resident Offices) of actual overhead rates and projected rates, including supporting detail by various elements of overhead. This data coupled with availability of data fr 01G's annual economic forecast would allow 01G to make their forecasts with more confidence. So far specific data by elements of overhead has only been available from one shipyard.

5.1.2 Competitive (Advertised) Fixed Price Bids (currently little used in ship procurement)

The budget forecast is updated by soliciting current overhead rates from the cognizant SUPSHIPS and or DCAA's the yards expected to bid. MARAD is also solicited for latest bid rates. Based on this 01G prepares an "average or "reasonable" overhead rate and submits to the negotiat prior to bid opening. (Ditto for labor and material.) I low bid is reasonable, there is no further analysis of th cost elements including overhead. If there is significan difference and a buy-in is suspected the negotiator notifies the bidder of a possible loss situation and ll bid overheads and other cost elements are reviewed by the cognizant DCAA office.

5.1.3 Negotiated Fixed Price/Incentive Fee

Where it is contemplated to negotiate a fixed price with a sole source, no independent estimates of cost including overhead are prepared or used as a reference, unless the contracting officer deems it desirable.

The contractor's proposal is subjected to a technical Analysis Review (TAR) procedures (see 5.1.5) in conjunction with an audit evaluation by the cognizant DCAA field office. Briefly the TAR establishes the reasonableness (for the contractor concerned) of the material quantity, quality weights, and labor manhours and the audit evaluation of the reasonableness of the contractor's proposed labor and overhead rates for the period in question. The audit report is expected to reflect the results of the technical evaluation. This data is submitted to the cognizant contracting officer as a basis for contract negotiations.

Where competitive proposals are solicited from several yards an estimate (independent of the TAR) is developed.

5.1.4 Cost and Incentive Fee or Cost and Fixed Fee

A similar procedure to that described above for negotiated fixed price/incentive fee is followed. On large cost type contracts such as TRIDENT the contractor may be willing to submit more data on the composition of his overhead costs as part of his proposal and in advance of DCAA audit.

5.1.5 Technical Analysis Review Procedure (TAR) and Audit Report

The distribution of responsibilities in connection with the development of the technical analysis and audit evaluation should be noted. It is as follows:

5.1.5 Continued

Project Engineer - Responsible through the Project Manager for coordinating preparation of the TAR

Acquisition Project Manager - (NAVSEA PMS) overall management and coordination of TAR preparation and negotiation of Technical requirements and specific responsibility for determining "adequacy of shipbuilder's management, facilities, manpower and the acceptability of delivery schedule".

NAVSEC - Review and evaluate proposal re material quantity, quality and weights.

NAVSEA Cost Estimating and Analysis Division (01G) - Analysis and verification of contractor's manhours and material pricing. Advise on request. Could be called on for an independent estimate.

NAVSEA 08 - Analysis and verification of nuclear plant costs.

PMS Technical Analysis - Coordination and validation of data to contracting officer.

SUPSHIPS - Technical Analysis, Assist Project Engineer and PMS teams to develop quantities, cost manhours and historical data.

DCAA - (Back up data from contractor's records via Supships.)

Audit Report - DCAA Resident Auditor directly responsible to contracting officer for comprehensive audit report including evaluation of overhead rates.

TAR preparation time and presumably the DCAA audit report on combatant ships require anywhere from three to twelve months.

5.1.6 Ongoing Monitoring of Overhead Costs

The ongoing monitoring of overhead costs is jointly shared by the resident DCAA audit office and the Supervisor of Shipbuilding's Business Analysis Group which reports to the Area Contracting Officer. The DCAA prepares periodic Audits of current overheads in conjunction with pricing of change orders and both organizations participate in prosecuting a cost monitoring plan for each fiscal year in accordance with NPD 70-702-5. This data is not currently supplied to 01G.

5.1.7 Applicability of DOD Construction 7000-2 Performance Measurement of Selected Acquisitions

It was reasonably recommended by NMARK (Cost 8) that 7000-2 be used as the medium for gathering cost data needed for budget and cost estimating purposes by 01G. However, it should be noted that of the "major" shipyards only two, Lockheed and Bath, are "qualified" under 7000.2. Electric Boat is in process of qualification. At Newport News there is apparantly no intent to qualify. The writer sees no reason why data under 7000-2 cannot be provided at the summary level suggested as necessary for meaningful analysis elsewhere in this report. At the present Lockheed reports cite only one overall overhead figure.

With respect to detailed overhead cost data supplied by contractors in support of proposals, the writer has verified that this is available at two shipyards:

Newport News (1975 - procurement of several submarines Fixed Price/Incentive Fee)

Electric Boat (Trident Proposal - Cost Type Contract)

In the case of the Newport News Data it was held in the DCAA file at the request of the Company and only a projected overhead % was submitted to the contracting officer. The TRIDENT data is in the contracting officer's file.

5.2 Overall Factors Bearing on the Adequacy of the Navy's Cost Estimates and Evaluation of Contractor's Cost Proposals

5.2.1. Distribution of Organizational Responsibilities

It is to be noted that while there is provision for covering all aspects of the cost picture in developing estimates and reviewing contractor's cost proposals the responsibilities are shared among eight or nine organizational entities, the process takes from three to twelve months and in effect the whole burden of estimate adequacy (except for budget estimates) appears to fall on the contracting officer. See ASPR 3-801.2.

In the specific matter of overhead, except for budget estimates, there appears to be no responsibility assumed within NAVSEA other than by the contracting officer and this is delegated to the cognizant DCAA audit office.

Since the minimum overhead for combatant naval ships in a period of price, wage and managerial stability is in the order of 25% of the shipbuilder's cost in some cases probably more than 30% it would appear that more attention by NAVSEA and specifically SEA 01, Deputy Commander/Controller (and within 01 by 01G cost estimating and analysis division) is merited.

Thus it would appear reasonable and even mandatory that 01G be given a more comprehensive mission with respect to monitoring overhead costs in major contractor's yards, development of a data bank and memory for those costs and responsibility to form independent estimates for overheads on negotiated procurements.

Overhead data from audits is available via DCAA in each of the shipyards regardless of the applicability of 7000.2 and the data should be obtained at a sufficient level of detail (10-12 summary accounts would do it) so that 01G's analyst can understand its composition, the

5.2 Overall Factors Bearing on the Adequacy of the Navy's Cost Estimates and Evaluation of Contractor's Cost Proposals (continued)

5.2.1 Distribution of Organizational Responsibilities (continued)

various cost drivers within it and relate them to their economic indicators. Table III, prepared using actual overhead data from a major shipyard shows the minimum detail considered appropriate.

Organizationally, the diffused responsibility for the reasonableness of the various elements of ship costs, including overhead which has the contracting officer as the focal point plus the reviews of the estimate at two levels above NAVSEA appears to put the Commander, NAVSEA almost into a titular position with regard to cost estimates. In this regard, and in reference to the Bureau system prevailing up until the mid 1960's the NMARK cost panel stated:

> "The Bureau chiefs felt a vary personel responsibility for the cost estimates and budget figures, the development and performance of the weapons and the overall weapons acquisition program. The Congress, the Secretary of the Navy and the Chief of Naval Operations knew who was responsible."

Some reorganization and realignment of responsibility for cost estimates within NAVSEA may help to restore this focus along with the elimination of at least one of the higher reviews. Also it would be prudent to follow good commercial practice and always have an independent cost estimate for a contract being let on a cost basis.

However, factors largely beyond the present control of NAVSEA have important influence on ship costs as discussed in 5.2.2, 4.2.4 and 5.2.6. These must be satisfactorily addressed at DOD level before full accountability for costs can be restored at NAVSEA command level.

5.2 Overall Factors Bearing on the Adequacy of the Navy's Cost Estimates and Evaluation of Contractor's Cost Proposals (continued)

5.2.2. Policy on "Reasonableness" of Contractor Costs

One also notes the recurring emphasis in various manuals, procedures and directives on auditing and evaluating the resonableness of costs within the content of a contractors past practice and environment. Specifically, Section IV e, Technical Analysis, Guidelines and Techniques, of the unofficial NAVSEA TAR manual states:

> "The purpose of the TAR analysis is to determine whether the data and logic submitted by the contractor reasonably support the conclusion (price, delivery schedule) of contractor. The technical analysis ....is not:
>
> - To be made on the basis of an independent estimate
> - A personal evaluation by the technical analyst
> - Based upon comparing a similar scope of work in another shipyard, private or Naval"

This policy apparently stems from ASPR.

Thus in the absence of an independent yardstick estimate there is no real means of determining at NAVSEA level that the Navy and the U.S. taxpayer are getting their monies worth on negotiated fixed price incentive contracts and cost type procurements. Determining reasonable allowability and accuracy of a contractors accounting practices through audit of contractor's costs does not insure that a shipyards direct labor manhours reflect an acceptable level of productivity or that its cost, including overhead costs, reflect acceptable management practices and management effectiveness.

5.2.3 Pre-award Determination of "The adequacy of shipbuilder's management, facilities, manpower and acceptability of delivery schedule"

This study did not include any investigation of the depth and effectiveness of pre-award surveys of "the adequacy of shipbuilders management, facilities, manpower and acceptability of delivery schedule". Presumably this is a team effort involving the cognizant PMS, 075, 077 and the local supships. Based on the frequency with which contractors have been unable to perform in accordance with their proposal, this would appear to be an area where considerable more effort should be expended as a means of avoiding schedule delays and cost growth resulting from overloading of yard facilities, management capability or the labor market involved.

For example, if a shipyard cannot comply with the principles of 7000.2, their ability to manage a naval shipbuilding program of any magnitude must be seriously questioned.

If audit of a particular yard's ability to handle the project has less than positive results and if no acceptable alternative is available, the Navy would at least be forwarned to exercise extraordinary precautions in the monitoring and auditing of performance so as to better perceive potential delays and overruns and insure that contractors take remedial actions and recast targets accordingly.

5.2.4 The Claims Phenomenon and Its Effect on Ongoing Costs

The situation described under 5.2.1 and 5.2.2 is not improved by the claims phenomenon where the bulk of the claims on fixed price contracts attempt to justify recovery of full costs incurred plus interest. Claim entitlement techniques based on this philosophy permeate all levels of shipyard management where they are espoused.

5.2.4 Continued

Further the procedures that are put in effect are the antithesis of the steps that should be taken to manage the program in question within the budget. They tend to promote overruns by perverting constructive management philosophy and practices at all levels of the organization and diverting management skills from timely planning and execution of ongoing work. The effect on all elements of direct and overhead costs are, in the writers opinion, substantial.

5.2.5 Handling of Overhead Costs in Claims

An examination of several recent shipbuilder claims was made to determine whether contractor data would give any insight into overhead cost drivers. The results were negative. Claim costs assume credit for incurred overhead and which, as a % of overrun direct costs, has generally been given tacit acceptance in connection with audits for change order pricing and advance pricing proposals.

Apparently the question of entitlement for overrun overhead $ costs in claims has never been questioned as such, but with overhead costs having increased markedly over the last decade and if the allocation of responsibility for costs in Table III of this study is reasonably accurate then, without taking into account the effect of any schedule slippage and assuming an 82% overhead, 34 of these overhead points are variable overhead within the control of the shipyard. To the degree that they are excessive from the point of view of optimum shipyard management - as opposed to acceptability from an accounting point of view there is massive opportunity for subtle but progressive deterioration in the ability of Navy to predict or control its costs. Vice versa the opportunity to avoid the incurrance of unnecessary costs through the stimulation of good management practices on the part of the few shipbuilders that remain in the combatant ship business is there and should be fully exploited.

5.2.6 Other Major Policy Issues

Other important factors affect the Navy's ability to control costs of ship procurement programs. These are:

1. The subcontracting of most of the Navy's "Scope" engineering - often to the very contractors who will eventually construct the ships.
2. The elimination of shipbuilding in the Naval shipyards.
3. The concentration of combatant ship programs in but three major yards.

In consequence of steps 1 and 2, taken some years ago, the ability of NAVSEA as a whole and its SUPSHIPS offices to apply the requisite degree of "know-how" based on experience in its appraisal of contractor cost proposals and in its on-going monitoring of contract cost performance on fixed price/incentive fee contracts and cost type contracts must by now have been seriously eroded. It must be successfully addressed if NAVSEA "control" over ship procurement costs is to be achieved. Substantial training programs for naval officers and civil servants including DCAA in private shipyards might be one solution. However, the reversal of steps 1 and 2 above would appear to be more practical and have the greatest potential. For example:

- On-going generation of in-house engineering and shipbuilding capability would be assured.
- With 7000.2 applied to new construction in the Navy Yards there is no reason why these cannot be meaningful comparisons of costs in Naval and Commercial yards.
- The Navy would not be as dependant on sole sources as at present.

Item 3 of course eliminated, along with the benefits of competition, sources of data on ship costs and overheads

5.2.6 Continued

At least one step has been taken to reverse step 3 above with Bath now building the prototype of a new class of vessel.

5.2.7 Observed Improvements in NAVSEA and SUPSHIPS and DCAA Operations

Several improvements are apparent in the organization of NAVSEA as compared to its predecessor organizations which may offset in part the erosion in overall technical capability noted in 5.2.6. Three of pertinence to management of costs and cost control are:

1. P.M.S. organizations are far more cognizant of costs, cost elements and more active in tracking them than were the old BUSHIPS "desks".
2. Business analysis groups in SUPSHIPS offices are an excellent concept and in the one office visited analytical studies of high merit are being prepared.
3. The DCAA operational audits being performed with technical support from SUPSHIPS personnel are comprehensive and penetrating and must have important beneficial impact on a shipbuilders cost performance.

With a better funded 01G cost estimating and analysis effort which would enable the assimilation of data and development of a memory for pertinent data - it would be most rewarding for 01G to establish much better communications with these groups and for that matter with other sources such as the contracting officers negotiating data files on costs.

5.2.7 Continued

If the Navy can reverse the erosion of its shipbuilding "know how" and improve the technical support given to DCAA in their audit function there appears to be ample opportunity for improved cost "control" and budget performance well beyond current achievement.

5.3. 01G Overhead Estimating Staff, Data Bank and Procedure

The 01G staff totals approximately 24 persons, twelve in cost estimating and twelve in cost analysis. One person (GS12) in the cost analysis group spends 40% of his time on the analysis of and projection of overhead cost %'s for all shipyards. As noted elsewhere, he has data from one yard in slightly more detail than that shown on Tables III and IV. Budgets for congressional submission stem from this effort (see 5.1). Three shipyards, Newport News, Litton and Electric Boat probably account for 70% or more of the total $'s spent on naval new construction in the United States. There are no more than 10 others building, or with any imputed capability of building, naval ships. The total expenditures on overhead $s in private shipyards building naval ships was not verified but it must be in the order of $500 M per year or greater in the above 3 yards alone. The size of the number alone would indicate greater attention to overhead costs at NAVSEA level.

If there is to be any meaningful analysis of overhead cost factors at NAVSEA level (by 01G) and development of a reasonable capability for making responsible independent estimates of overhead, it is the writers estimate that the present nominal effort should be augmented by an overhead cost group comprising at least 3 GS 13s or 14s who have the following qualifications:

- A degree in Naval architecture and Marine Engineering.
- 2 - 3 years experience in actual shipbuilding and ship design.
- A MA degree in business management.

5.3 01G Overhead Estimating Staff, Data Bank and Procedure (continued)

These should be supplemented by an equal number of secretary-clerks and a travel budget which would have each of these 3 principals in the field (where the information is) at lease 1/3 of the year.

It should be noted that the NMARK study noted the need for increasing the budget for 01G and numerous requests have been generated and endorsed up through the Chief of Naval Operations with but scant results to date.

Additional staffing would then enable 01G to use overhead estimating procedures analagous to those used in private industry. In addition to the availability of specific $s by overhead account which could be related to economic cost drivers they should also have up to date forecast work loads from the various yards which include all firm business in hand plus a best estimate as to the likely and a best guess as to potential business. This data should be available both from SUPSHIP and 075. With it in hand and kept up to date the confidence factor with respect to the realism of 01G's budget estimate for overhead should greatly improve and 01G would be able to make meaningful "independent" estimates of overhead costs for us in support of "independent" estimates of ship costs as a cross check of the TAR/audit check of contractors proposals for negotiated procurements.

5.4 Optimum Application of 7000-2 - Performance Management of Selected Acquisitions

7000-2 appears to offer the best hope for systematically collecting data pertinent to improvement of cost analysi estimating and forecasting within NAVSEA as well as the Navy' overall "control" over shipbuilding costs.

With respect to overhead cost elements the overhead accounts need not be standardized between yards but the data must be provided by meaningful summary accounts.

In a well managed shipyard experienced in building combatant ships for the Navy the incremental cost of compliance with 7000.2 could scarcely be measured. A good commercial yard starting from scratch to qualify under 7000.2 might temporarily add two percentage points to its overhead rate.

As noted elsewhere, the Navy will only be able to take full advantage of the better visibility of contractor's operations and its improved, better organized data base to the degree that it is staffed in the appropriate spots with the requisite technical, and managerial, and analysis skills that have been developed in the process of actual building ships as opposed to supervision or auditing thereof. (The shipbuilding skill problem is discussed under Section 5.2.6 of this report.)

Assuming however, that 7000.2 can be applied in all yards building combatant ships and the "skills" problem is solved, then the use of 7000.2 can be extended and made to pay off even further to the advantage of both the Navy and the contractor and to an extent that is perhaps not yet fully perceived.

This would be by developing from the 7000.2 data base a computerized (deterministic) network of the program includi all specific tasks involved in the engineering, design, plan approval and construction of the ship(s) and the progress-

5.4 Optimum Application of 7000.2 - Performance Management of Selected Acquisitions (continued)

ing the contract in terms of the model. Since the timeliness and appropriateness of management and engineering decisions in the eary part of the program set the stage for schedule and cost performance including overhead costs and since the feedback from the network or "model" to both contractor and Navy would be simultaneous important improvements in communications, timely actions on changes of all classes and better control of individual shipbuilding programs from all aspects should accrue. Not the least of these would be manageable data base of actual direct costs for finite tasks of defined scope and a matching overhead costs for defined accounts.

Such a model developed for a private shipowner has proved practical in connection with a commercial shipbuilding claim. It has the potential for tremendous benefits in the field of claim avoidance.

6. Summary of Findings and Recommendations

It must be recognized that this study was of limited duration and involved examination of overhead costs from but one shipyard. Thus while it was in sufficient depth to model the various elements of overhead with respect to their variability and sensitivity, the data should not be used as a basis for forecasting the future course of overhead costs without analysis of a broader data base.

In analysing the elements of overhead we took some liberties in dividing the elements up between

- Human related "variable" costs
- "Semi-Variable" costs
- "Fixed" costs.

The first two catagories are largely variable with direct labor and have increased as a % of total overhead from 83% in 1969 to 86.6% in 1975 and we guess that they could be about the same in 1980. These variable costs are of course extremely sensitive to direct labor, its efficiency and the effectiveness of the shipyard management system. The efficiency of the management system will also be reflected in the level of indirect employees required and the % of indirect to direct labor. We did not attempt to quantify this effect on the overhead rate except in our modeling of the effect of delay. Neither did we in this study attempt to quantify the effect of labor turnover, absenteeism, training costs and variations in workload or overhead.

"Social" pressures for higher fringe benefits have been an important driving force in increasing both overhead $s and overhead rates (see Table IV). Changes mandated by law have increased substantially between 1969 and 1975 and represented 23% of the total rise due to social pressures, which in total more than doubled the 1969 fringe package. Dramatic as these increased have been they should not becloud the fact that fringes along with the bulk of overhead are variable costs and in that sense controllable.

6. Summary of Findings and Recommendations (continued)

We have not repeated in this summary the results of our analysis of overhead costs which can best be assimilated by scanning Tables I through V inclusive and Table VI which models the effect of delay on overhead.

The study results speaks strongly for consistent and continuing use and analysis of overhead data at NAVSEA level for all important shipyards and the results as represented by the tables and discussion thereof in the body of the report along with the results of our investigation of organization and procedures form to basis of our findings covered in Section 5 and the recommendations which follow.

Recommendations:

1. The overhead cost area in private shipyards building Naval ships represents a fertile field for analysis, constructive operational audits by DCAA and the Navy and potential for costs savings by stimulating improved management of the yards.
2. Analysis of overhead costs at NAVSHIP level should be provided for. It is meaningless to do it in terms of overhead percentage. It should be done using specific costs and at least to the degree of detail suggested in the exhibits to this report.
3. Program delays do affect overhead costs significantly. The promptness and effectiveness of management reponse to delay will determine the amount of overhead delta generated. It is therefore vital that personnel of the highest quality and training in complexities of shipbuilding and shipyard management be assigned to monitor and constructively influence contractor performance on cost and incentive fee contracts.

6. Summary of Findings and Recommendations (continued)

Recommendations (continued)

4. It would appear reasonable, profitable and even mandator[y] that OIG be given a far more comprehensive mission with respect to monitoring overhead costs in major contractor yards, development of a data bank and memory for those costs and responsibility to develop independent estimates for overheads on negotiated procurements using data from the shipyards that can be conveniently channel[ed] through 7000-2 reports where 7000-2 is applicable.

5. In conjunction with 4, above NAVSEA should review its organization and procedures for cost estimates which now heads up to the contracting officer as the focal point. At least, prudence would indicate the need for having independent NAVSEA estimates regardless of the type of contract.

6. Full accountability for costs and cost estimates at NAVS[EA] level will not be possible until the important influence[s] on costs that are at present beyond the control of NAVSE[A] are satisfactorily addressed at DOD level. These are:

   - Correction of ASPR regulations and ASBCA philosophy which encourages contractors to believe they that through the "claims" route recover substantially on cost overruns regardless of fault, thus infecting their organizations with philosophies and procedures which in themselves generate excess and unjustifiable costs.
   - Restoring the engineering and shipbuilding capability and know-how of NAVSEA by reestablishing on-going in-house ship "scope" engineering and design and reintroduction of shipbuilding in Naval shipyards; needed for many reasons - but specific to this report to reinforce the DCAA/SUPSHIP audit function and therefore the Navy's ability to illuminate the potential for improved management of shipyards.

6. Summary of Findings and Recommendations (continued)

Recommendations (continued)

7. Review the handling of overhead costs in claims with respect to acceptability in those areas where effectiveness of shipyard management can be questioned.

8. Fund 01G consistent with the mission relative to overhead costs suggested in 4 above.

9. Organize a drive to better apply 7000-2 and realize the benefits to both Navy and shipyards that are to be gained from its use including its "potential" for generating timely, truely effective management of shipbuilding projects by both Navy and contractors and to the end of excess cost and "claim" avoidance.

10. Intensify the depth of pre-award determinations of "the adequacy of shipbuilder's management facilities, manpower and accountability of delivery schedule". Where any or all of these elements are in question, and if an award is contemplated, make final award and funding contingent on the shipbuilder developing an acceptable management, manufacturing and production plan and proving it in a simulated exercise of perhaps a computerized model.

APPENDIX I

References

Armed Services Procurement Regulations (ASPR)

3-701.3	Overhead (indirect costs)
3-801.2	Contracting officers' responsibilities for establishing a negotiating baseline
15-203	Contract cost principles and procedure (indirect costs)

Department of Defense Instructions

7000-2	Performance measurement for selected acquisitions
7000-10	Contract cost performance and funds status report
7000-11	Contractor cost data reporting CCDR

Navy Prouncement Directives

20-702.5	Monitoring contractor costs

NAVMAT Notices

4330	Establishment of contract cost monitors in SUPSHIPS dated 21 March 1974

NAVSEA

Technical analysis review (TAR) Manual - undated

Instructions: 5400.3 Charter for attack submarine acquisitio[n] Project (PMS 393)

5400.1 Cost estimating and analysis division (SEA 052) 1 July 74

01G yearly economic forecast for 1976

NMARK Study - Cost Panel Section VII 1-15.

SUPSHIPS Instruction 4335.1A - 5 October 1976 - Cost Monitoring Pla[n] for f/y 77 - (per NPD-20-702-5) and NAVMAT 4330

APPENDIX II

Activities Visited

Nava Sea Systems Command

		Persons Interviewed
09.	Vice Commander	RAdm. K. E. Wilson
01.	Financial Management/Controller	
	01G Cost Estimating and Analysis Division	G. H. Main
		J. A. Fetchco
02.	Contract Directorate:	
	02B. Asst. Deputy Cdr.	G. McBride
	022. Chief Negotiator	Wm. Manson
	E. B. Trident Negotiator	Baker
	028. Contract Administration	Capt. Ronald Jones
07.	Industrial and Facilities Management	
	077. Contracts Performance Division	G. W. Holthaus
PMS 393	Attack Submarine Acquisition Project	Capt. T. M. Hopkins
	Project Manager	J. T. R. Wakefield
	Financial Management Branch Head	Cdr. R. M. Kreimer
PMS 383	Aux. Amphs and Special Mission Ship Acquisition	Douglas Adams
SUPSHIPS	Newport News Supervisor	RAdm. Eustice
	Deputy	Capt. J. F. Yurso
	Business Analysis Group	Billy H. Smith
	Manloads	Earl J. Fraley

Defense Contract Audit Agency

Washington		E. J. Hill
	Program Manager - Shipbuilding	Amster
Newport News Resident Auditor		J. C. Picot, Jr.
	Supervisory Auditor	W. D. Ferrebe,Jr.

EXHIBIT D.2

FACTORS AFFECTING SHIPYARD PRODUCTIVITY

D-485

February 1977

D.M. MACK-FORLIST

CONTENTS

SUMMARY

The purpose of this report is the review and evaluation of a number of factors which affect shipyard productivity either in terms of physical output per labor hour or in terms of final cost or both. The evaluation is based on a survey at a number of major shipyards, which have extensive experience in Naval shipbuilding, and at several other organizations and, in part, on previous experience and studies.

An order of importance for most of the factors and a quantitative evaluation for a few has been established on the basis of the survey. Most of the participants in the survey considered it impossible to make a sufficiently accurate, general quantitative estimate of the potential effect of the factors on productivity. A great degree of agreement on the general nature of these effects was developed in the survey and is presented in the report.

In addition, a range of quantitative effects has been estimated, based on the author's general experience and other recent studies. Estimated ranges of productivity and cost effects of related estimating factors had been developed previously. They were published in a paper on estimating at the last annual meeting of the Society of Naval Architects and Marine Engineers. In discussion at the meeting the approach to the problem and the ranges of magnitued assigned to the factors were not questioned.

On the basis of the survey and the above studies it is concluded that a combined maximum unfavorable effect of all factors may lead to doubling the labor hours and increasing cost by half over previous performance.

It is extremely important, therefore, to evaluate all factors, including some judgment of magnitude where a more accurate method is not available, and to adjust accordingly base estimates, which are based on previous performance.

For procurements involving offers from several shipyards it is advisable to repeat this process for each shipyard separately. The individual factors may have quite different effects from each other for any program and different effects for different shipyards in the program.

LIST OF TABLES

INTRODUCTION

This report is prepared for the International Maritime Associates in accordance with a mutual agreement of the 11th of January, 1977, and a work outline of the same date. The purpose of the study is the identification and analysis of the effect of a number of factors on shipyard productivity which, in turn, affects Navy estimating of shipbuilding costs.

Productivity can be considered either in terms of output per unit of labor--hours, mandays, etc.--or output per unit of labor cost--labor dollars, labor and overhead dollars--or some other combination of costs of production. Some of the factors affect labor hours, others the cost of labor, some affect both as well as other production costs.

In some cases it is possible to arrive at a quantitative evaluation of the effects. For many factors this study must be limited to general analysis and identification of trends and orders or ranges of magnitude.

The factors considered in the study are:

1. Stability of operations,
2. Labor availability and turnover,
3. Automation and mechanization,
4. Shipyards' engineering capabilities,
5. Learning (series production),
6. Social legislation (OSHA, EPA, EEO, FICA, etc.),
7. Training programs,
8. Labor agreements,
9. Increased complexity of ships,

10. Shipbuilding market,

11. Inflationary trends,

12. Other economic trends,

13. Special Navy considerations:

    a. Contract form and administration
    b. Changes under the contract
    c. Inspection and plan approval
    d. Quality control
    e. GFM and GFI
    f. Delays
    g. Overall complexity

Some of these factors affect productivity directly, others only through their impact on general operating conditions. Some must be considered in either of these two groups, depending on the measures of production which are used.

A great variety of productivity measures has been used in shipbuilding. Some of the more frequently used are:

For input -
1. Direct labor hours
2. Total labor hours
3. Total employment
4. Total cost of labor
5. Capital investment - total or annualized
6. Combined cost of labor and capital

For output -
1. Value added
2. Compensated gross registered tons (merchant ships),
3. Ton-mile per unit time carrying capacity (merchant ships)
4. Tons of structural steel processed, using various weighting factors
5. Mission effectiveness

The conclusions concerning productivity will depend to a considerable extent on the selection of the measures. Even the units for the measure

which is selected are, to a degree, a matter of accepted procedures, conventions and some judgment.

Classification of hours as direct or indirect, for example, depends on accounting procedures which differ between U.S. yards and differ very widely internationally. Cost of labor depends on the accounting treatment of some costs, e.g., accrual or current costing of such items as vacations and on direct or overhead charging of labor related costs. Capital costs records are effected by depreciation rules and procedures. Value added is distorted in inflationary periods. Compensated gross registered tons depend on the internationally agreed conversion factors. Structural steel is a good measure for relatively simple and similar ships, such as tankers and simple break bulk carriers, but even there the weighting faqotrs inject a very large element of judgment. Mission effectiveness is almost entirely a matter of judgement, even with the most rigorous and complex models and it is rarely, if ever, available for actual full scale, controlled operating tests.

The way in which this affects the various factors is discussed in the fourth section of this report--Evaluation of Factors. The treatment of the factors in estimating is considered in the next following section--Effects on Estimating.

In selecting the measures for this report importance was attached to continuity, so as to be able to consider trends. This required measures which are reasonably stable, i.e., are affected as

little as possibly by cyclical and other changes external to the shipyard. This is discussed further in the next section.

GENERAL APPROACH

The collection of information and the analysis made for this report were directed to three principal objectives:

1. Obtain discussions of the factors and their effects from shipyards and other valid sources, supported in all cases by reasons and general experience and, when possible, by specific quantitative data.

2. Obtain from shipyards information on their experience of the effects of the factors in Naval construction in particular.

3. Obtain general statistical data showing conditions in the national economy and contemporaneous conditions in shipbuilding. The information, if possible, to cover a sufficient period to show trends.

Available sources of information related to shipbuilding costs and problems were sought. In all cases productivity was discussed in some detail. The results of the interviews were analyzed and combined.

Relationships between the factors and trends over time were studied.

Universal measures of shipyard output do not exist. The effects of the factors are therefore evaluated in terms of their impact on the input. To maintain continuity, the measures used are total labor hours or employment. In a few cases, such as FICA and inflationary trends,

cost of labor and material are considered and discussed separately. While the evaluations are based on the above measures, they are not, as discussed previously, necessarily quantitative.

One quantitative indicator of the overall long-term labor productivity trends in the construction of merchant ships is available. This is the output of compensated gross registered tons (CGRT) per employee per year. It is widely used and was used by the Commission on American Shipbuilding to show trends of labor productivity in U.S. shipyards for a ten-year period--1960-70. The study has been extended by the author for five years--1971-1975--using consistent methods. While it does not include any Naval construction, it does include the shipyards which did or are doing both Naval and merchant shipbuilding and it gives a clear indication of the general trend in labor productivity in these yards over an extended period.

Where the information obtained supports a consensus this is stated in the report. In some cases, a range of opinions resulted from the interviews; this is reported accordingly. The author's conclusions are stated separately.

The consensus or range of opinions and the author's conclusions concerning individual factors are presented in the fourth section of the report--Evaluation of Factors. The sources of information and the limitations of the study are discussed in the next section.

SCOPE

Sources of Information

The nature of the information underlying this report has been discussed in the previous section. The sources were:

Major United States shipyards

Naval architects and other consultants

Industry organizations

Government agencies.

The shipyards, Naval architects and other consultants which were interviewed were selected on the basis of being engaged in Naval construction or design at present, or having been engaged in it in the recent past and having shown interest in re-entering the Navy market. All those approached responded to the inquiries. In almost all cases the interviews and discussions were at the senior management, in one or two cases at the senior technical level. Because of the nature of the information and opinions, organizations and individuals who supplied it are not identified in the report.

Relevant previous reports were also consulted. Some of the principal publications are listed in the bibliography.

The Principal Factors

The factors listed in the introduction may not be all which affect shipyard productivity. They are, however, all which have significant effects. They can be classified in the following groups:

1. Internal shipyard conditions (factors 1, 3, 4, 5, 8)
2. Form of contract and contract administration (factors 13a-f)
3. Economic conditons including labor market (factors 2,10, 11, 12)
4. Specifications and technology (factors 9, 13g)
5. Legislation and regulations and their interpretation (factors 6, 7)

The types of impacts on productivity by these groups are shown in Table 1. The effect on productivity can be measured with any accuracy only in some of the cases. The relation of the different factors to the technology of the ship and of production is also indicated in the table.

Limitations

Quantitative conclusions are limited by the nature of available information. Even when a reasonably reliable quantitative evaluation is possible, the effects may be different in different shipyards, for different types of shipbuilding programs and under different conditions of performance.

Actual records of the impacts of different factors on productivity are almost nonexistent. In almost all cases, quantitative statements concerning gains or losses of productivity were based on estimates.

Data were furnished and opinions expressed with the understanding

TABLE 1

DISTRIBUTION OF FACTORS AFFECTING PRODUCTIVITY BY GROUPS

Groups of Factors	The Factor Influences			Productivity Effects of Factor		
Affecting Shipbuilding Productivity	Design of Ship	Production Methods	Organization	on Hours	Cost of Labor	Fairly Measurable
Internal Shipyard Conditions	x	x	x	x	x	x
Form of Contract and Contract Administration		x	x	x		in part
Economic Conditions including Labor Market			x	x	x	in part
Specifications and Technology	x	x	x	x	x	x
Legislation & Regulations and their Interpretation		x	x	x		

that the sources and specific items of information would be treated as confidential.

These conditions impose limitations on the scope. The very short allowed time is a further limitation.

EVALUATION OF FACTORS

Information was received from fourteen organizations including seven major shipyards; three were government agencies and one a major manufacturer, only general information was obtained from them. The opinions presented in the subsections of this section are those of the shipyards, Naval architects and industry organizations. The information was obtained in interviews in all cases and supplemented by written reports in a few.

Each of the factors listed in the Introduction is discussed separately in this section. Some of the factors, however, are interrelated, e.g., stability, shipbuilding market and other economic trends. Each of the factors affects more than one of the variables which enter into the preparation of estimates and bids and, in almost all cases, more than one factor affects any one of the variables. (See Table 2)

In a number of cases, therefore, several factors were grouped together in discussion during the interviews. Where this occurred, it is noted in the relevant subsections. The opinions of the participants are summarized in each of the subsections. An overall summary and the author's opinions are presented in the last part of this section--Quantitative Evaluation.

TABLE 2

INTERRELATION OF FACTORS & ESTIMATING CONSIDERATIONS

VARIABLES
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The Variables below are grouped by the magnitude of their effect on shipbuilding costs.

VARIABLES	1 Stability of Operation	2 Labor Availability and Turnover	3 Automation and Mechanization	4 Shipyard Engineering Capability	5 Learning Series Construction	6 Social Legislation	7 Training Programs	8 Labor Agreements	9 Increased Complexity (All Ships)	10 Shipbuilding Market	11 Inflation	12 Other Economic Trends	13a Contract Administration	13b Changes Under The Contract	13c Inspection And Plan Approval	13d Quality Control	13e GFM & GFI	13f Delays	13g Complexity (Navy Ships)
Class 1																			
Other Work in Yard	X	X			X	X	X	X	X		X			X	X			X	X
Manpower Levels	X	X	X					X			X			X			X	X	
Escalation				X					X					X	X		X	X	X
Status of Design																			
Class 2																			
Efficiency of 1st Ship					X														
Learning	X	X			X												X	X	
Material Support				X					X					X	X		X		X
Pre-Outfitting		X		X				X						X	X				
Overtime			X																
Facility Start Up	X		X	X					X								X		
Detailed Planning										X		X		X					
Follow-On Business	X	X																	
Class 3																			
Design Agent				X					X					X	X				
Technical Creep				X										X	X				
Specification Enforcement													X		X	X			
Supervision & Support	X	X					X		X										
Direct/Indirect	X	X											X					X	
Strikes	X	X										X						X	
Catastrophes																		X	
Facility Shortcomings			X		X														
Tooling			X		X														
Process Improvements	X							X			X	X							
Make/Buy		X										X					X		
Vendor Negotiations									X				X		X				X
Sole Source Procurement									X			X							X
Vendor Failures				X					X			X			X				
Bulk Buys																			
Loss & Scrap																			
Special Wage Rates								X											
Government Regulations	X	X				X		X	X	X			X	X				X	
Fixed/Variable Overhead								X					X	X				X	

Monetary measures would be difficult and, possibly misleading during the recent and still continuing period of high inflationary rates. Wherever possible, therefore, the interviews discussions of quantitative effects on ranking of the factors were in terms of manhour input and physical output. The discussion in the report is on the same basis, unless noted otherwise.

The manhour basis also has the advantage of continuity when trends over time are considered. It was used in estimating productivity trends.

Stability

Stability is the operating condition for optimum productivity, --the measure of or point of reference for the evaluation of the actual past, present or projected productivity. Stability, or the lack of it, affects primarily labor hours and, to a much lesser extent, cost factors such as fringe benefits, FICA, overhead in general, etc.

It includes not only a stable level and composition of the workforce, but also continuity of type of workload, the structure and manning of the organization, stability of methods, tools and facilities. This does not imply that all of these will or should remain constant, but that the affect of departures must be carefully considered in estimating.

Of the ten participants whose opinions were solicited all but one ranked stability as the principal factor affecting productivity. The one different opinion was based on measuring productivity in monetary terms; in this one case, inflation, complexity, labor agreements and social

legislation were ranked as more important cost factors than stability.

In discussion, stability was coupled with labor availability and turnover by nine participants and with the shipbuilding market and other economic trends by one.

Five participants offered quantitative evaluations. One estimated that lack of stability would reduce labor hour productivity by as much as 35% below normal optimum levels. One other estimated an increase of about 4% in total cost of the ship. The degree of departure from stability could not be expressed quantitatively. Three additional opinions on quantitative effect were expressed when stability was discussed in the context of labor availability and turnover; they are presented in the next section.

Labor Availability and Turnover

All participants coupled this factor with Stability. Most coupled them when ranking the factors.

Three offered quantitative evaluations. In their experience, when the workforce is being built up above established levels, the productivity of the new employes averages about one half of the productivity of the starting workforce for periods of one year and more in such crafts as pipefitting for over two years.

It was said, in discussion, that the loss of productivity would depend on the magnitude and rate of buildup; it may be possible to absorb buildups of 5% or even 10% of starting level, if the buildup is very gradual.

Conversely, the loss is greater than one half if the buildup is very rapid. It was the general opinion that the rate of loss is greatest at first and tapers of gradually; the shortest period for attaining a normal level of productivity was considered to be one year in skilled crafts.

The quantitative evaluations were made for the fairly recent and the present conditions of the labor market. The range of estimated losses for the total force would depend on the proportion of new employes. In one case, the opinion was expressed that a rapid decline in force level would cause losses of about one half the magnitude of the losses caused by buildup.

Automation and Mechanization

All participants said that automation in the strict sense was virtually non-existent in shipyards and, to the extent it existed, was not a significant factor. Semi-automatic and mechanized operations were of some importance,

All particpating shipyards had made major investments in new facilities in the recent past. Not all were willing to assign a rank to this factor. Only one ranked it as high as 3, the others from 6 to 11. In one case the principal value of this factor was considered to be the increase in total volume of output.

In almost all cases, cautions were voiced concerning start-up problems of new facilities. In several cases, it was stated that improvements in productivity are not realized for substantial periods after installation of new facilities. It was also said that, for some period, the savings in labor

costs are balanced, in great part, by the costs of amortization and depreciation and more sophisticated maintenance.

Shipyards' Engineering Capabilities

Opinions varied from "minor importance, but a positive factor" to "a necessary capability". Only about half the participants were willing to assign a rank to the factor; when assigned, the rank was fairly high, varying from 2 to 6.

Learning (Series Production)

Nine of ten participants assigned a fairly high value to this factor. The ranks varied from 3 to 5. There was one opinion that learning, in the sense of ship to ship manhour gains, does not exist under present labor conditions.

Quantitative evaluations varied quite widely from 85% to 93% for each doubling of the number of ships. Two opinions were quite general--that the learning improvement was greatest for complex ships and that the curve tends to be flatter than the above exponential after eight or ten ships.

Several participants pointed out that the term "learning" masks a very complex process. It includes individual learning, the adaptation of management and production procedures, the development of new methods, the better design and material support for the later ships of a program and so forth.

Social Legislation

The effect of this factor was ranked high by the participating shipyards. With two exceptions it was ranked either 4 or 5.

In two of the above cases the ranking was in terms of cost and not manhour productivity. In the other cases the effects of OSHA and EEO were emphasized. In one case a very low importance was attributed to this factor, but it was pointed out that this depended on some special operating conditions of that yard.

In several cases, the capital costs arising from OSHA and EPA requirements were discussed. It was pointed out that over the last several years they ran well into the seven figures.

Traning Programs

In discussing this factor, a distinction was made by almost all participants between the shipyards' own programs and government financed outside programs. Shipyard training, both school and on-the-job, was considered a normal and essential part of operations in to-days labor market. The comments on the government financed programs were not favorable in general.

About half the participants ranked this factor number 7, two ranked it 10 and 11 respectively. In terms of quantitative evaluation, its effects were considered part of labor availability and turnover. It was pointed out, however, that the labor hour effects represent only part of the cost of training programs, since the time spent by trainees in school and the other

costs of operating the schools are charged to overhead.

Labor Agreements

The shipyards which have labor agreements ranked this factor from 6 to 8. One yard combined the effects with the training programs for a joint rank of 7.

In general, the major clauses of both IUMSWA/CIO and AFL agreements are similar. The principal emphasis is on seniority, grievance procedures, arbitration, lay-offs, union security and check-off. The definition of fringe benefits is second, particularly in the IUMSWA agreements; this includes life and health insurance, pensions, holidays and vacations. Safety and health provisions occupy a prominent place.

In all yards the cost of fringe benefits has been increasing more than labor rates. In general, labor rates have increased by about 80% from 1965 to 1975, earnings have increased less because of the decrease in hours worked per week (Table 5). During the same period the cost of fringe benefits has increased about 165% on the average in most U.S. yards. In some of the yards, participating in this survey, the cost of fringes has increased substantially more. On the average, therefore, the cost of fringes has been increasing 40% - 50% faster than the labor rates. In most major yards it now equals over 40% of the wage cost.

This has a significant bearing on another factor -- inflation. The provisions covering labor escalation in most shipbuilding contracts are based on wage indece, occasionally with separate provisions for taxes, e.g., social security. The additional cost of the more rapid growth of

fringe benefits is, therefore, not protected by the escalator clauses.

Increased Complexity

It was the general opinion that the complexity of all ships had increased greatly and was still increasing and that it had a major impact on the cost of ships. The complexity of Naval vessells and its effect is discussed separately in the last subsection of this section.

The effect on productivity is more complicated, because the increased cost has two components. One is the actual value of the additional hardware and the increased difficulty of the more complex work; the other is the cost of inefficiencies caused by the complexity.

The inefficiencies arise from congestion, interferences, more extensive testing, equipment incompatibilities, equipment failures, greater difficulties with vendor information, problems of vendor selection. These are losses which can be observed and, to a great extent recorded. There is another aspect of this factor, which affects the overall productivity of the yard.

The more complex work is almost always more labor intensive than such standard operations as hull steel, bilge and ballast and ordinary steel piping, electrical power plant, etc. It also requires greater or more uncommon expertise in engineering, production administration, and supervision and more infrequent blue collar skills. This changes the available workforce composition and imposes demands which are hard to meet in a limited labor market.

There was a considerable spread of opinions in ranking this factor, from 1 to five and one very low rating of 12.

Shipbuilding Market

The shipbuilding market affects productivity through several of the other factors. Stability is affected directly, labor turnover through changes of programs, mechanization through changes in funds for capital investment with changes in market outlook, learning through limitations on long runs of similar ships. Even labor agreements are affected, because the business prospects affect the positions of the company and union negotiatiors.

The shipbuilding market is subject to great fluctuations worldwide. These fluctuations are reflected to a great extent in U.S. merchant shipbuilding. The Naval vessel market varies greatly for other reasons.

During the last ten years, the number of Naval ships ordered in one year varied from fifty-four (54) to six (6). The number of merchant ships varied from forty-eight (48) to eight (8). The highs and lows of the two parts of the market did not coincide, but even the combined number varied from seventy (70) in 1966 to fourteen (14) in 1969 and sixty-two (62) in 1972. (Source: Shipbuilders Council of America.)

This fluctuation of total numbers is coupled with major changes in the types of ships. Most of the programs involve long building periods so that the changes in the order books are not reflected directly in changes in operative levels. The impact on the factors mentioned above is, nevertheless, great and is reflected in losses of productivity.

If output is measured in dollars, -- value added or value of shipments, -- the market fluctuations also have a direct effect on apparent productivity. Market conditions govern pricing, particularly in a market, such as shipbuilding, comprising few buyers, few sellers and few product units. In a shrinking market the dollar output for a given physical output will shrink.

The majority of participants said that the market factor was part of or reflected in stability. Only three assigned a separate rank to it; this varied widely from 1 to 6.

Inflationary Trends

This factor is reflected almost exclusively in the dollar values of input and output. Two of the participants pointed out that it also affects employe morale. Two others said that major inflationary spurts may lead to vendor problems and, in some cases, vendor failures. This, in turn, would damage material support and productivity.

Only two participants assigned an independent rank, 1 and 2 respectively. The second was assigned with the qualifying statement "at this time".

Inflationary trends are not uniform in different sectors of the economy. Inflation will, therefore, tend to distort productivity measures in much the same way as was discussed in the previous subsection.

Other Economic Trends

Only three participants expressed a direct opinion on this subject.

All three said that the effect on productivity was indirect through one or more of the other factors. The ranking varied widely from 1 (Combined with stability) to 9.

General economic conditions affect shipping directly and, therefore, the shipbuilding market. They affect inflationary trends and cost of materials and labor as well as the availability of materials and labor. They bear heavily on availability of money for capital investments.

It is probably impossible to project a direct quantitative impact. It is possible to estimate some range of impact through other factors such as labor availability and turnover, labor agreements, shipbuilding market and inflationary trends.

Special Navy Considerations

Five of the participants combined all factors in this group in assigning a rank. The others ranked one or more of the component factors. In all cases, except one, the combined rank or the rank of one or several of the component factors was from 1 to 3. The one exception was a rank of 8 for productivity in terms of manhours but a rank of 1 in terms of effect on productivity in dollar units.

The comments on the several subheads under this factor follow:

Contract Administration

All participants said that the administrative work, particularly paperwork, was excessively costly. Several said that it impinged on the organizational structure and, therefore, affected productivity. Several

commented in different terms on the adversary attitude generated by the administrative procedures; it was said or implied that this attitude caused unproductive efforts, complicated the shipyards' management structure and, in the long run, affected the productivity of the physical construction work.

Only two participants ranked this factor separately. They ranked it 3 and 7.

Changes under the Contract

All participants discussed this factor at some length. Only one ranked it separately. In all cases this factor was identified as a source of major problems. It could not be ranked or otherwise evaluated in advance because the number, magnitude, configuration and timing of changes are unpredictable.

Opinions differed concerning the relative magnitude of the impact of a few major changes as against the combined effect of a great number of minor changes. The participants were unanimous in the statement that the effect of changes on productivitity became more damaging when changes were introduced at more advanced stages of construction. Several emphasized the bad effects of uncertainty arising when the development and authorization of changes extended over long time periods.

It was also an unanimous opinion that the hours used and cost of a change exceeded the hours and cost of performing the same work as part of the original contract and that the excess hours and costs increased as the

introduction of the change was delayed. In the majority of discussions it was pointed out that introduction of massive changes affected the entire yard and not just the ship or group of ships to which the changes applied.

Inspection and Plan Approval

Few participants discussed this factor to any extent. Those who did said that it was a relatively minor problem. One or two mentioned inspection delays, particularly in testing, as irritants having some effect on morale.

Quality Control

All participants discussed this factor. With one exception it was ranked individually by those who did not assign one rank to the combined Navy consideration. These ranks varied from 3 to 6.

The emphasis in the discussions was on the formalized nature of the MIL-SPEC type of control. It was questioned whether the results justified the cost or improved over the inspection and supervisory control practiced in merchant construction.

GFM and GFI

Only one participant ranked this factor separately as 2 or 3. The comments of the others varied from "drastic and unpredictable impact" to "no problem". Participants whose experienced was primarily with combatant ships appeared to attach more weight to this factor than builders of auxiliaries.

Delays

There was no discussion of delays as an independent factor. They were mentioned as a part and outgrowth of the problems arising from contract changes and, less frequently, in connection with GFM and GFI.

The associated costs were discussed. The emphasis was on inflationary costs and on losses of productivity arising both from the stand-by nature of some of the shipyard service manning and from loss of momentum in the principal production crafts.

Overall Complexity

This was ranked separately by all participants who did not assign a joint rank to all Navy considerations. The ranks were 1 or 2, except for one 3. This factor also was emphasized in discussion.

The discussions centered on weapons systems and to a lesser degree on complexities in Navy design of features which parallel merchant ships -- e.g., hull structure. In weapons systems three problems were emphasized:

Integration,
Repeated changes,
Experimental nature.

The three conditions are interrelated to an extent, their impact may be felt at different levels of the shipyard organization and at different points of the production process. In all cases the impact is major.

Here, again, the labor hours and cost required to accomplish the individual work items - must be considered separately from hours and

costs of congestion, interferences, delays and developmental activities arising from the integration effort and the experimental aspects.

Summary of Survey

There is substantial agreement among the participants in the survey on most of the factors. There was close agreement on the order of importance of thirteen of the nineteen factors. Three of the remaining six are factors which affect productivity, as defined in the discussions only indirectly, -- shipbuilding market, inflation, other economic trends.

This does not detract from the great importance of these factors, but makes it very difficult to evaluate their effect. There is a tendency to consider them through their effect on other factors, as discussed in the several foregoing subsections.

The prevailing opinion of the participants in this survey concerning the order of importance of the factor was as follows (See Table 3):

Stability combined with labor availability and turnover	1st
Navy considerations	2nd
Learning (Series production)	3rd
Social legislation and training	4th
Labor agreements	5th

Considerable importance was attached to some of the other factors by some of the particpants, but there was no clear majority opinion.

TABLE 3

SUMMARY OF SURVEY INFORMATION

FACTOR	CONSENSUS Rank	CONSENSUS Magnitude Pre-dictable	CONSENSUS Magnitude Measur-able	RANGE OF OPINIONS Rank	RANGE OF OPINIONS Magnitude Pre-dictable	RANGE OF OPINIONS Magnitude Measur-able
Stability of Operations]	1 or 2	Yes	Yes (3)			
Labor Availability & Turnover]						
Automation & Mechanization				3-11	Yes	Yes
Shipyards' Engineering				2-6	Yes	(5)
Learning	3-5	Yes	Yes			
Social Legislation	4-5	No	Partially			
Training Programs	7	Yes	Yes			
Labor Agreements	6-8	Yes	Yes			
Increased Complexity				1-5	Yes	Partially
Shipbuilding Market				1-6 (7)		
Inflationary Trends				1-2 (8)	Partially	Partially
Other Economic Trends				1-9 (7)	Partially	No
Navy Considerations						
Contract Administr.]						
Changes under Contract]						
Inspection and Plan Appr.]						
Quality Control]	1-3	No	Partially			
GFM and GFI]						
Delays]						
Overall Complexity]						

NOTE: (Number) Participants who did not express an opinion

In some cases, the difficulty of reaching a consensus arose from difficulty of defining the ways in which the factors affected productivity or of defining and agreeing on units of measure. There were some differences of opinion concerning the relative merits of output per manhour or total cost being the best measure of the effects of some of the factors.

Some differences in evaluation were the result of the shipyards' experience on important programs. A few differences were caused by particular operating conditions associated with the shipyards' business structure or general background or location.

The great majority did not make quantitative evaluations of the factors except as discussed in a few of the foregoing subsections. Many of the participants felt that the way in which most of the factors affect operations, the probability of their occurance and their extent and timing are not sufficiently predictable for advance quantitative evaluation.

In this respect, the author differs from the majority opinion in part. This is discussed in the next subsection.

Some additional factors were suggested in one or two of the discussions. They included location, material support, planning and scheduling, work management and management-employe relations.

They are not discussed in the report for several reasons. As regards location, most of the yards engaged in major programs depend ultimately on the national labor market; regional characteristics tend to be overshadowed by national trends when major numbers of employes are involved. Where a

shipyard has and maintains a stable labor force this is a vital factor, but it is a characteristic of the shipyard and its management rather than any local conditions. Material support interrelates with several of the factors (see Table 2) and will be considered in that context. The several other factors are vital tools and supports for productivity, but in the framework of this report it is considered that these operations or conditions must be adequate in a shipyard being considered for the award of a major Navy contract. To some extent, these latter factors are also reflected in such estimating variables as pre-outfitting, detailed planning, process improvements. Each of these variables interrelates with several of the factors in this report (see Table 2) and will be considered in that context.

Quantitative Evaluation

The assignment of the quantitative values to the factors is difficult for two reasons:

> It is not possible to predict the occurance and its time, magnitude and duration for many of the factors.
>
> The factors represent operating conditions rather than estimating units or variables. They are interrelated, they overlap and each affects or is affected by a number of estimating variables.

As discussed in the foregoing parts of this section, participants in the survey combined two, three and more factors in making their order of importance, qualitative evaluations. It is shown in Table 2, that each factor affects or is affected by from one to ten estimating variables.

Some ranges of magnitude are indicated by the survey. One measure is provided by the quite generally accepted estimate of the relative low efficiency of new and untrained employes. Two participants offered fairly complete quantitative evaluations of the survey factors or, in part, similar and parallel conditions.

One of these evaluations shows manhours more than doubling if all of the factors have their maximum adverse effects. The second evaluation was in terms of cost and indicates that total cost would increase by about 50%, possibly more, if all factors had their maximum unfavorable effect. Assuming that purchased material and services are about half of the total shipyard cost and considering that almost all of the factors in this second evaluation affect manhours, this also suggest that manhours would be about doubled in the maximum adverse case.

It is this author's opinion that it is possible to assign ranges of magnitude to many of the factors. This is discussed below.

Stability has been defined for the purposes of this report as the optimum condition of operation. Losses of productivity caused by the factors are evaluated in terms of departures from this condition. The ranges of magnitude assigned to these losses are based on the experience and the studies underlying the quantitative evaluation of the estimating variables in the paper presented at the last annual meeting of the Society of Naval Architects and Marine Engineers. In this case it was also concluded that manhours would be more than doubled, if all variables were at the maximum adverse level.

The evaluation of the factors is discussed below:

1. Loss of Stability -- this is best measured in terms of accession of untrained employes on the basis that each such employe will work at one half normal efficiency for a year to a year and a half. This does not include the effects of losses of the other aspects of stability, discussed previously, if they occur. A measure for these losses is not available.

2. Labor availability and turnover -- this is the basis for the measure in Item 1. That measure is applicable to the recent and present labor market. Major changes in the market may require a re-evaluation.

3. Automation and mechanization -- most major U.S. shipyards have all or most mechanized and semi-automated equipment available for the industry. In the case of major facility changes to be applied to a new program, the initial effects will be adverse because of start-up problems.

   Most facility improvements produce large savings in relatively small parts of the operation. Many are directed to increases in total capability, rather than increases of productivity, -- e.g., large building docks or shipways.

   Finally most semi-automated facilities favor savings in phases of construction which represent a minor part of the work on a Naval vessel. A 20% saving in hours at present cost levels would probably require a $6,000,000 - $10,000,000 investment per 1,000

employes. The favorable effects would not be felt for some time after completion of the improvements.

4. Shipyard's engineering capability -- the lack or loss of such capability may cause losses of manhour productivity of 5% - 15%.
5. Learning (series production) -- this may be lost because of labor conditions, insufficient or excessive intervals between the ships of a series, because of inadequate design or material support, for other causes. An 85% to 90% improvement for each doubling of a number of ships is reasonable for Naval vessels up to eight to twelve ships -flatter thereafter. The much steeper curves of the wartime yards are not applicable to present operations, because the conditions are completely different. If conditions are anticipated which would lead to the loss of manhour improvement, the resultant increase in manhours can be calculated on the above basis.
6. Social Legislation -- some effects such as social security, taxes can be anticipated accurately. The effects of OSHA, EEO and EPA regulations have to be considered for each individual case. Much of these effects is already part of present performance levels of U.S. shipyards. Depending on the condition of a particular yard, there may be an improvement in the future or, particularly in the case of expansion, a further detrimental effect on productivity -- losses of 5% - 10% in labor productivity appear possible.

7. Training programs -- the manhour effects of such programs are considered in Item 1. The overhead costs for an existing or proposed program can be calculated when its scope is determined. Losses of about 5% in the productivity of the existing workforce may occur because of the need for additional supervision and the interference of the on-the-job trainees with the experienced workers.

8. Labor agreements -- cost increases such as labor rates, escalator clauses, bigger fringe benefits in the existing agreements can be readily estimated. If the labor agreement for the shipyard involved expires during the proposed program a projection of probable increases can be made on the basis of the changes in past agreements, changes in recent agreements of other yards and the business climate reflected in the shipbuilding market and other economic conditions.

9. Increased complexity -- this has been discussed before in this report. It will be discussed further in connection of the complexity of Naval equipment, particularly weapons. If major new and complex design features (other than weapons) are included in a new ship, losses of 5% - 15% in labor hour productivity may occur and some losses, probably up to 5%, will almost certainly occur.

10. Shipbuilding market -- the effects of fluctuations will be reflected in the first instance in the loss of stability (Item 1) and are included there. The effects on pricing have been discussed, changes of 5% - 10

in price levels can be anticipated when major market changes occur.

Some of the effects of market fluctuations are shown in Table 4. A great part of the increase in employment was in the major constructic yards. The manpower build-up in those yards was proportionately greater than the overall manpower growth. This had a significant effect on productivity, which is discussed later.

11. Inflation -- this was a minor factor in the United States for many yea: and a major one for three or four years. Provision must be made fo: inflationary trends. This cannot be limited entirely to the projection of the escalator index, because this does not cover all cost increases and such increases are or may be treated separately in shipyard pricing.

12. General economic trends -- this must be considered in making forecasts for almost all of the items discussed in the foregoing. In doing so, it is important that the shipbuilding industry does not necessarily follow the general economic pattern.

The earnings and wages in shipbuilding rose more rapidly than in some comparable industries during the recent recession. On the other hand, they are lower than contract construction - the chief competitor for some of the critical skills. (Table 5.)

Prices of shipbuilding materials rose much faster than the general level of prices. (Table 6.) The output of the industry fluctuated

TABLE 4

EMPLOYMENT and TURNOVER

	National*		Private Shipyards **	
Year	Employed 1,000	Unemployed %	Employed 1,000	Turnover %
1960	65,778	5.5		22.6
61				21.3
62			114.6	20.5
63			115.5	20.3
64			116.8	21.7
65	71,088	4.5	128.9	18.8
66			143.6	17.7
67			140.0	17.5
68	75,920	3.6	141.0	17.7
69	77.902	3.5	142.0	16.3
70	78.627	4.9	132.7	15.4
71	79,120	5.9	130.6	17.2
72	81,702	5.6	138.1	15.9
73	84,409	4.9	143.9	15.4
74	85,936	5.6	153.9	13.9
75	83,549	8.6	153.6	12.2
76 (March)			165.9	14.5

Source
* Statistical abstract of the United States - p. 343.
** Shipbuilders Council of America.

TABLE 5

HOURS and EARNINGS

Year	Weekly Hours			Weekly Earnings *		
	Contract Construction	Durable Goods	Shipbuilding & Repair	Contract Construction	Durable Goods	Shipbuilding & Repairs
1961	36.9	40.3	40.0	118	100	117
62	37.0	40.9	40.4	122	105	122
63	37.3	41.1	41.0	127	108	128
64	37.2	41.4	40.7	132	112	128
65	37.4	42.0	40.5	138	117	128
66	37.6	42.1	41.5	146	122	138
67	37.7	41.2	40.5	155	124	140
68	37.4	41.4	40.5	165	132	145
69	37.9	41.3	40.7	181	140	155
70	37.4	40.3	39.9	196	143	158
71	37.3	40.4	39.5	213	153	163
72	N.A.	41.3	39.6	N.A.	168	173
73	N.A.	41.5	38.7	N.A.	180	178
74	N.A.	40.7	38.1	N.A.	191	190
75	N.A.	39.9	39.4	N.A.	205	217
76 (July)	N.A.	40.5	39.2	N.A.	225	235

* Rounded to nearest dollar.

Source
Shipbuilders Council of America

TABLE 6

COST INDICE
(1967 - 100)

Year	Prices * Consumer	Prices * Wholesale	Prices * Iron & Steel	Navships ** Material
1965	94.5	96.4	97.9	N.A.
66	97.2	98.5		N.A.
67	100.0	100.0		100.0
68	104.2	102.5	101.9	N.A.
69	109.8	106.0	107.0	N.A.
70	116.3	110.0	115.1	N.A.
71	121.3	114.0	121.8	118.9
72	125.3	117.9	128.4	123.3
73	133.1	125.9	136.2	128.9
74	147.7	153.8	178.6	159.6
75 (p)	160.0	169.7	201.1	182.9

Source
* Statistical Abstract of The United States - 417, 419, 422.
** Shipbuilders Council of America

widely but continued rising when output levels in durable goods and transportation industries were falling. (Table 7)

13. Special Navy considerations -- as a group, this was ranked second in the survey. The factors in this category may be divided into three groups for purposes of evaluation:

Contract administration, inspection and plan approval, quality control and GFM and GFI,

Changes under the contract and delays,

Complexity.

It must be assumed for the purposes of this evaluation that the factors in the first group are operating well, without controversies or delays. In that case they will involve only administrative and engineering functions and require personnel to the extent of 1% - 3% of the total yard force. If these activities do not operate well, it will be reflected initially in delays. This will cause escalation costs and losses of labor hour productivity of 5% - 10%, depending on the stages of construction, because part of the manning of service and support crafts is time related rather than output related. Further effects in terms of long delays and interferences and disruption cannot be evaluated in advance.

The effects of changes and associated delays depend on the type and magnitude of the changes and the stage of construction when the changes are authorized, almost always, however, productivity on change work is lower than normal shipyard productivity, even apart from possible delays.

TABLE 7

SHIPMENTS AND VALUE OF WORK DONE
(1967 - 100)

Year	Index of Production * Durable Manufactures	Index of Production * Transportation Equipment	Value of Work ** Done Self Propelled Ships
1960	63	64	57
61			62
62			66
63			69
64			76
65	89	91	77
66			83
67			100
68			102
69	110	108	98
70	101	90	120
71	99	93	121
72	108	99	143
73	122	109	115
74 (p)	121	97	151
75 (1st q.)	105	79	N.A.

Source
* Statistical Abstract of The United States - p. 731. (Constant Dollars)
** Bureau of the Census. (Current Dollars)

14. Complexity -- this has been discussed before, in the applicable section of the survey and in Item 9 above. The complexity of Naval vessels is usually concentrated in the weapons and the associated parts of the ship and its equipment. In this part of design and construction there is almost always a great amount of changes and what amounts to experimental work. This has a severe impact on production procedures and on the workforce.

    It is not possible to assign even a range of loss of productivity to all possible variations of this factor. This type of work cannot, however, be performed at the levels of productivity which would prevail for similar work units which form parts of other systems.

GENERAL TRENDS

Two indicators of general trends of productivity in United States shipyards are available. One relates to merchant ship construction only and measures productivity in compensated gross registered tons per employe per year. The second is an unpublished series of the Bureau of Labor Statistics, dated February 2, 1976, for the years 1958 through 1973; productivity is measured in terms of dollar output per employe hour for all shipbuilding and repair (SIC 3731).

The first series shows an improvement of productivity of about 13% for the period 1967-70 compared with the average for the entire ten years 1961 - 70. This is followed by a drop of almost 17% for the five years 1971-75 compared with 1967-70. This is a fairly rough measure, but change

of magnitude are sufficient to show a trend. Considering the greater complexity and, therefore, greater demands on labor skills for Naval vessels it is probable that the decline of productivity on that work in the 1971-75 period was greater.

The second series shows a similar, but less pronounced, improvement trend for 1967-70 compared with the entire 1961-70 average. The data for 1971 and later are not sufficient for a conclusion.

EFFECTS ON ESTIMATING

The considerations discussed in the two preceding sections affect estimating. In some respects, they affect Navy and shipyard estimating differently because of differences in the purposes and in data availability.

The purpose of the Navy estimate is the determination of the final full cost of the ship to the Navy. This includes the cost of GFM and GFI, the Navy cost of plan approval, inspection and testing, some other cost items and the market price of the ship. The latter may be, but is not necessarily the biggest single cost item. For this report, it is the only cost item under consideration and the effects of the productivity factors will be discussed in that context.

The purpose of the shipyard estimate is the determination of the cost of construction to the shipyard. In competitive procurements it is also important to the shipyard to forecast the market price, but this is done separately from the estimate and not necessarily by the estimating department.

Some parts of the eventual price are cost to the Navy but not to the shipyard, e.g., escalation, sometimes social security, etc. Conversely, some items are cost to the shipyard, but are not included in the final price unless they are separately estimated and provided for in the bid. e.g., inflationary costs which are not covered by the escalation provisions. Some items are of importance to the shipyard and of no interest to the Navy, e.g., many of the make/buy decisions.

The essential difference is that the Navy estimate must reflect the probable low position of one of a group of yards except in the case of sole source procurement; the shipyard estimates its own cost. The shipyard has the complete set of all relevant data. This includes past performance on similar ships and past performance on similar systems or similar parts of systems, if similar ships have not been built before. It also includes the conditions under which this past performance was accomplished and the knowledge of the changes in conditions and capabilities since then. The Navy can have only partial knowledge of these data.

The Navy's estimate is, therefore, akin to a shipyard's budget estimate or a shipyard's estimate for a major capital appropriations. These estimates, in general, have a lower level of accuracy than bid estimates; suitable margins are, therefore, needed. Some corporations recognize this by routinely allowing 10% overruns in capital appropriations with supplemental authorization by top corporate management. In one way or another, margins must be allowed in this type of estimate over and above estimated cost.

For the purposes of applying the factors, it follows from the above that --

1. Each factor must be considered and evaluated.
2. Quantitative evaluation is not possible in some cases, but these factors must also be considered and a judgment made of their effect,
3. This judgment must be included in the projected evaluation of the total effect of all factors, which is applied to the estimate,
4. Recent experience and existing conditions must be considered when projecting the effects of the factors. Linear projections are often inadequate.
5. The factors interact. Their combined effect may be greater than an arithmetical sum of their individual effects.
6. The present positions of the prospective offerors must be analysed in order to apply the factors.

The last point is essential to any quantitative evaluation.

The estimated magnitudes in the last part of the section on evaluation of factors are based on the assumption that they represent departures from the optimum operating condition -- stability. (See subsections on Stability and on Quantitative Evaluation.) Evaluation of the effect of any factor on the productivity of a shipyard will depend on the actual operating conditions which are used in comparisons of performance and costs and as a basis for estimating.

If, for example, a shipyard's previous performance and pricing were in a period of workforce build-up and turnover and the projections for the proposed program show a reasonably stable workforce, this factor will result in cost reductions. If, on the other hand, the learning curve in a

previous, similar program started with a poor first ship performance, the learning improvements must be assumed to be smaller in the proposed program. This applies for all factors and the conditions of the base or comparison period or program must be considered separately for each. It is entirely possible that improvements of productivity can be anticipated for some of the factors while others will have detrimental effects on the same program. The final costs of the previous program or programs, used as the basis for the current estimate, must be adjusted for a factor by factor comparison of the previous and the projected conditions of performance.

This comparison should also include the workloads of the shipyards concerned. The shipbuilding market will govern general price levels, but the price of any shipyard will be based primarily on its own position and, in the second place, on its evaluation of its competitors' positions and of the market outlook in general. The application of the factors to estimates for a competitive procurement is, therefore, a very complex exercise in judgment.

CONCLUSION

The survey of participating shipyards and several other participating organizations shows that the factors reviewed in this report are generally believed to have major effects on shipyard productivity. In order of importance, in this respect, stability of operations and workforce were considered first, special Navy considerations second, improvement by series production third, social legislation and training fourth and labor agreements fifth. There was not general agreement on the relative

importance of the other factors. Many participants felt that the effects of such factors as shipbuilding market, general economic conditions and increasing complexity were reflected in the factors, which are ranked above.

Only a very limited number of quantitative evaluations are available from the survey. Such evaluations are, however, made in the report on the basis of previous experience and other recent studies.

On that basis, it is concluded that manhours may be doubled and cost increase by half over previous performance if all factors have their greatest unfavorable effects. This conclusion coincides with the survey data, to the extent they are available.

The factors are of such importance that they should be evaluated quantitatively whenever possible and the evaluation should be further adjusted, by judgment, for the probable effects of the factors for which only a qualitative approach is possible. This should be done separately for each factor, because their effects may differ widely for any one program. When several shipyards are considered for a program it is advisable to make such evaluations for each of them.

BIBLIOGRAPHY

Basic Facts on Productivity, Fabricant, S., National Bureau of Economic Research, Inc., 1959.

Bid Preparation in Shipbuilding, Mack-Forlist, D.M. and Goldbach, R.A., SNAME, paper No. 10, 1976.

Cost Estimating, Ship Design & Construction, Dart, C.E., University of Michigan, 1970.

Directions for Improvement in Productivity, Schaeffner, C.R., Webb Institute of Naval Architecture, 1972.

Development of Initial Program Estimates, Grosson, J.F. and Rakow, W.O., Naval Engineers Journal, February, 1975.

Financial Effects of Labor Turnover, Pearce, Frank T., Research Board, Faculty of Commerce and Social Sciences, University of Birmingham, England.

Improving the Prospects of U.S. Shipbuilding, Webb Institute of Naval Architecture, 1969.

Labor Turnover Calculation and Cost, Gaudet, Frederik, J., American Management Association, 1960.

Manufacturing Management, Moore, Franklin G., Richard D. Irwin, Inc.

Measuring Company Productivity, Kendrick, J.W., National Industrial Conference Board, 1965.

Measuring Productivity in the U.S. Shipbuilding Industry, Lando, M., Center for Naval Analysis, 1969.

Multi-Year Ship Procurement, Bannerman, G.C., Naval Engineers Journal, December, 1967.

Potential for Reduced Ship Construction Subsidy, Mack-Forlist, D.M., Webb Institute of Naval Architecture, July, 1972.

Productivity and Research in Shipbuilding, Joint Industry Committee, London, 1962.

Productivity Measurement, OECD, 1974

Shipbuilding: The Long-term Orderbook Begins to Decline, Hawkins, R., Seatrade, February, 1972.

The Cost Savings of Multiple Ship Production, Couch, E., International Shipbuilding Progress, August, 1963.

The Meaning and Measurement of Productivity, Bureau of Labor Statistics, 1971.

The Prediction of Shipyard Costs, Summers, L., Marine Technology, January, 1973.

U.S. Government -

Bureau of the Census, Statistical Abstract 1975, pp. 343, 349, 356, 358, 417, 419, 424, 601/2, 734, 851. Output in Shipbuilding and Repairing (SIC 3731).

Bureau of Labor Statistics, Output per Employee Hour for SIC 3731 (unpublished data), February, 1976. Productivity Indexes for Selected Industries, 1976.

Commission on American Shipbuilding, Report to the President and the Congress, 1973.

Comptroller General of the U.S. - Report to the Congress, Ways to Increase U.S. Shipbuilding Productivity, September, 1976.

26 February, 1977.

M E M O R A N D U M

SUBJECT: Periodic checks of shipbuilding productivity levels and Navy estimating units.

The discussion in this memorandum is directed to labor hours. The recent problems of cost overruns have been primarily labor hour problems. Material cost overruns have, in general, resulted from delays and associated inflationary costs.

Estimating units must be based on previous performance. It is necessary to know the conditions under which this performance was accomplished and to compare them with existing and prospective conditions in order to apply and adjust the units for proposed programs. It is necessary to have a point of reference.

Recent Navy programs do not provide a point of reference, because the costs have been distorted by abnormal conditions which are reflected in the shipyard claims. For this purpose, it is immaterial whether the claims are Navy or shipyard responsibility. In either case, the costs are abnormal.

The point of reference must be in preclaim ships built in the several shipyards. The labor hour returns of the yards at that time must be evaluated for the contemporary productivities of the different yards. These productivities should, then, be compared with the current performance levels of the same yards.

It is unfortunate that this involves going back ten years and, in some cases even more. Meaningful more recent returns do not exist.

Most shipyards have made major facility improvements since then, but these improvements have been primarily in the hull structural area and the effect on Navy ship construction is relatively minor. The panel shops may reduce the hours by as much as 60% from the assembly platen hours for corresponding work, but all structural assembly hours are only 20%-25% of all hull hours; these, in turn, are only 20%-25% of all labor hours for the ship. The panel shop saving is, therefore, about 2.5%-3.5% of all hours. Assuming a further 15% saving of all structural hours for the big cranes, transporters, etc. for the other hull hours, the total facility saving may be 6½% of previous performance. Given favorable schedules, the better facilities will permit more preoutfitting for suitable work items - say as much as 15% for one half of all remaining work. The total for all facility savings on all work of about 12% of all hours.

This is a very significant item, but it can be evaluated with the cooperation of the shipyards. This is a critical "if" and will be discussed further later in the memorandum.

The further adjustments to previous performance standards can be made as described in my report. Again, the cooperation of the shipyards is necessary for good accuracy.

Once this has been done for the shipyards concerned, a new, current point of reference has been established which can be used for any proposed programs - with suitable adjustment for anticipated future changes in the conditions of performance.

Two cautions:

1. This is a short term remedy,

2. Even the short term remedy requires a change in the present adversary Navy-shipyard relations.

The entire process is also contingent on the independance of the estimating and budgeting activities from other administrative and, even more, political considerations. These must be taken into account for trade-offs between different programs and for obtaining the best overall budgets, but must not be allowed to enter into the estimating and budgeting the coxsts of individual programs.

In the long term, good periodic checks on productivity and associated adjustments of estimating units will, I believe, depend on

1. Developing a matrix which relates the major productivity factors, which reflect operating conditions directly, to estimating factors or variables, which can be evaluated more accurately at the estimating and technical administrative levels,

2. Establishing a cost and work breakdown structure which is related to the way that the reflects the shipyards actual performance of the work and is broken down into a sufficient number of items.

It is necessary to have the cost breakdown correspond to the shipyards' work methods, because that is the way in which the costs are actually incurred and recorded and in which the the planning, scheduling and cost control are exercised. At best, the translation of the shipyard returned costs into the Navy nine or ten item breakdown introduces inaccuracies and guesses.

Moreover, at least fifteen different major skills and several auxiliary operating groups are involved in building a major ship. A nine or ten item breakdown cannot reflect this operation adequately.

Once the breakdown structure is established, the data for the long term estimating base can be obtained from the shipyards. The Navy has, of course, access to the shipyard returns both directly and through DCAA. The data will, however, be fully useful if they are recorded in association with and interpreted concurrently in the light of the operating conditions - both external and internal to the shipyard - under which the performance is made. This requires cooperation with the shipyard and a free flow of information and discussion during construction.

There will always be some restraints on this flow between owner and contractor. Under the present adversary conditions this flow is nonexistent and not really possible. Anyone familiar with the former Navy-shipyard relations knows that up to about twelve or fifteen years ago the conditions were very different and the mutual information flow fairly free.

The outlook is none too good. Even the short term solution which I recommend would need a year or more of very intensive work and a considerable degree of cooperation. The long term base would need several years to establish. It should be established separately, at least for the four or five shipyards which are most directly involved in major Navy programs. The reasons for separate data for the several shipyards are the same as the reasons for establishing the data base on shipyard records - any general base will be inaccurate in its application.

Even if all of this is done, the projection of conditions for the duration of a major program will be the source of doubts and inaccuracies. For that reason, the projections must be conservative and the budgets must have substantial margins. Any other approach must lead to overruns.

D.M.M-F.

EXHIBIT D.3

THE RATING SYSTEM FOR EMPLOYEE CAPABILITY

In order to measure the capability of personnel to analyze cost data and make cost estimates required in SEA 01G over the period of 1966-1976, the documents illustrated in Tables D.1 and D.2 were designed for use during desk interviews of present and former professional personnel. These forms include elements of education and experience which were considered essential for the work involved.

Column (1) recorded the years of experience or education by individuals up to the date of interview. Column (2) contains a relative rating weight for each item. The base rating (and one which is of primary importance) is that assigned to cost estimating (or analysis) performance and this factor was given a rating of "1". All others varied from more important to less important and were weighted accordingly. These weight values are an average of six independent opinions, three by SEA 01G supervisors in the applicable branch and three by the study group. The value for "other" experience was based on its closest relationship to experience or education listed previously. Column (3) was the product of Columns (1) and (2). Its total sum was a relative measure for current total capability of the individual in the current year.

TABLE D.1

EVALUATION OF COST ESTIMATING BRANCH

EXPERIENCE	(1) Years	(2) Rating	(3) (1)x(2) Weight
Cost Analysis		.9	
*Cost Estimating		1.0	
Cost Estimating Supervision		1.3	
Weight Estimating		.6	
Weight Estimating Supervision		.7	
Engineering Design		.6	
Engineering Design Supervision		.8	
Budgeting/Scheduling		.6	
Shipyard Estimating		.8	
Shipyard Production		.6	
Shipboard Service		.4	
Other Construction Experience		.4	
Other			
Supervisor's Rating 1-10*			
EDUCATION			
Vocational School		.3	
College: Engineering		.6	
College: Other		.3	
Graduate: Engineering		.7	
Graduate: Other		.4	
Special Training, related		.5	
Special Training, unrelated		.2	
Other			
TOTALS			

NAME OF EMPLOYEE ____________________

COMMENTS:

TABLE D.2

EVALUATION OF COST ANALYSIS BRANCH

EXPERIENCE	(1) Years	(2) Rating	(3) (1)x(2) Weight
Cost Estimating		1.0	
*Cost Analysis		1.0	
Cost Analysis Supervision		1.4	
Accounting/Auditing		.7	
Economic Analysis		.8	
ADP		.6	
Shipyard Cost Analysis		1.0	
Other Construction Cost Analysis		.7	
Other			
Supervisor's Rating 1-10*			
EDUCATION			
Commercial School		.4	
College: Business		.8	
College: Other		.7	
Graduate: MBA		.9	
Graduate: Other		.5	
Special Training, related		.8	
Special Training, unrelated		.3	
Other			
TOTALS			

NAME OF EMPLOYEE ______________________________

COMMENTS:

In order to have the calculation reflect the quality of each individual's performance, a supervisors rating was applied to the Cost Estimating or Cost Analysis element in the rating form. The supervisors rating could range from one to ten with average performance rated as five. For example, if an estimator had ten years of cost estimating experience, the product of column (1) x column (2) would equal ten. If the supervisors rating was eight then the adjustment would be $10 \times \frac{8}{5} = 16$.

Adjustments were made as applicable for back years to the first year of employment in SEA 01G or to 1966, as the earliest year, and a total was obtained for each back year.

EXHIBIT D.4

AID TO NAVAL PROCUREMENT
(Proposal By National Steel and Shipbuilding Co.)

It is proposed that the Navy take a page from the practice of the Air Force, in part, and cause to be created and fund a private nonprofit corporation to act as technical consultant to the Navy on ship procurement.

Because of historical developments, technical expertise in the aircraft and missile fields has been vested almost exclusively in private industry. The Air Force has never had a substantial in-house design capability. The Air Force needed to quickly create a highly competent and reliable (free from conflicts of interest) capability to evaluate and monitor the technical output of the private aircraft and missile contractors. This was achieved by funding, through the years, a number of private, nonprofit corporations which were created solely for this purpose.

The Navy has had for many decades, and still has, a complete in-house design capability. This in-house capability should be maintained, and possibly improved. Contrary to the aircraft and missile industry, the shipbuilding industry does not have substantial capability in the design of complex combatants. It would be counterproductive to attempt to duplicate their design capability in the shipbuilding industry or to transfer it from the Navy to

industry. However, in the present circumstances the Command functions of the Navy are captive to a sole source technical capability--their own in-house design section. The Navy needs a reliable capability to evaluate and monitor the output of their in-house design section. The Navy cannot properly look to the shipbuilding industry or to naval architects for this function because of the inherent conflicts of interest. However, the Navy could achieve this capability by funding a private, nonprofit corporation created and structured for this purpose.

Since the structure of the Navy-Shipbuilding Industry is different than the structure of the Air Force-Aircraft & Missile Industry, the size and functions of a private, nonprofit corporate consultant would be different. It is envisioned that a staff and annual budget ranging from 50 people ($10 million) to 100 people ($20 million) could perform the functions immediately envisioned. The foregoing budget estimates are gross and probably very conservative. However, this magnitude of cost would be completely justified if the principal objectives are achieved, which are: (1) Reduction of Naval shipbuilding costs, and (2) prevention of shipyard claims.

Principal functions of the consulting firm would be:

A. Participate in the ship procurement process in the following particulars:

(i) Review and comment on the technical and business aspects of the procurement package before issuance. It is anticipated that a large number of defects in technical plans and specifications could be eliminated by this review. This would substantially reduce the source of many subsequent claims from shipyards. In addition, many of the more technical contract provisions, such as progress payments and escalation can be improved by review.

(ii) Participate in the bidder's conference. This would provide a more objective third party analysis of the questions and points of view submitted by shipyards.

(B) Review of vessel designs to lessen the cost of production. There has been a running debate through the years between shipyards and the Navy on the subject of producibility. A captive consulting firm could effectively bring to bear on this issue an objective third party expertise.

(C) Review of the staffing and procedures of the Navy's design section to lead to improvement.

(D) Provide a "second opinion" to the command function of the Navy on technical questions as they arise. At the present time, Navy decision makers, when faced with a technical decision under an existing contract, can choose only between the technical opinions of the Naval personnel who originated the design and the contractor who is building the ship. A source of

reliable, objective, technical opinion is needed and could be provided by a consulting firm.

EXHIBIT D.5

DEFINITION OF THIRTY PERCENT DESIGN

1. The 30 percent design submission shall include, as a minimum, the following:

    (a) Preliminary project design estimates
    (b) 30 percent project specification in outline form
    (c) 30 percent preliminary drawings
    (d) Back-up data as required by this Chapter

2. The preliminary project design estimates are required with the 30 percent complete drawings and specifications and should reflect current costs as estimated from the preliminary drawings, design, computations, basis for design, and outline specifications. For those elements of the project where status of design does not permit a firm or reasonably accurate takeoff of the quantities or firm pricing of individual items of work, lump sum based on parameter costs may be included. The basis of these costs such as cost per square foot or building, per square yard of pavement, or per mechanical or electrical fixture shall be given.

3. The 30 percent specification shall be in outline form and shall consist of a complete listing of all specification sections to be included in the project specification. The listing shall be arranged in the sixteen division format of the Construction Specification Institute (CSI) and sequentially by section number. The number, title, and date of the guide specification being used in preparing each project specification section shall be listed under the appropriate division heading. The major materials or systems selected for each section, whether or not based on a guide specification, shall be listed for each project specification section; however, detailed specifications are not required for the selected materials or systems. All sixteen divisions shall be listed for every project. Where there is no work required in a particular division, a statement to that effect shall be included under the division heading.

4. The 30 percent preliminary drawings shall contain, as a minimum, the following documentation:

a. Site Plans showing all buildings in the project, access roads, parking, topography, survey control points, bench marks, drainage, roads and sidewalks, and routing of water, sewer, gas and other utilities.

b. Architectural Floor Plans showing complete functional layout room designations, all major dimensions, all critical dimensions, all columns, and all built-in equipment.

c. Elevations showing all openings, type and extent of building finishes and finish grading at building.

d. Building Sections indicating relationship of various levels, floor to floor heights, construction systems, and materials.

e. Preliminary Finish Schedule indicating proposed finishes.

f. Tabulation of all Net Areas for spaces limited by criteria or program.

g. Tabulation of Gross Building Area by floors and total building. Delineate areas computed with small-scale single-line dimensioned drawings.

h. Justification for deviation from areas required by criteria or program, or by deviation from approved concept drawings.

i. Preliminary Furniture Layouts showing that adequate wall space, circulation area, etc., are provided to accommodate the intended use of the space as follows:

(1) Spaces requiring specific accommodations (example - 200 seat assembly room).

(2) Typical BEQ bedroom, showing location of wardrobes, and providing optional single and double bunking plans.

(3) Major spaces with multipurpose use requirements which will require significantly different furniture arrangements for different uses.

(4) Where building design will dictate special design furniture, schematic details sufficient to define nature and extent of special items should be included. This applies whether special design furniture items will be included in plans and specs or procured as collateral equipment.

(5) Repetitive spaces which form a major component of the design. (Show typical layout for BEQ bedrooms, school classroom, etc.).

j. Interior mechanical/electrical documentation and/or data showing HVAC, plumbing, and electrical details to include:

(1) Design criteria
(2) Heating/cooling source
(3) Design analysis/energy studies
(4) Location of major equipment (for plumbing, show fixture locations and basic riser diagrams)
(5) System Diagrams, to include all ventilation systems
(6) Control diagram for mechanical systems
(7) Line diagram for electrical systems

k. Exterior mechanical/electrical documentation and/or data showing central heating/cooling plant and electrical distribution details to include:

(1) Plant loads
(2) Plant capacity
(3) Plant floor plan/general arrangement
(4) System diagram
(5) Fuel storage general arrangement
(6) Route of existing exterior heat, power, communication and fire alarm systems including capacities
(7) Routing and capacities of new systems

l. Civil/Structural details and data showing:

(1) Boring plans and logs
(2) Type of foundation system planned. Allowable soil bearing if spread footings are to be used
(3) Design loads (live load, wind, seismic, etc.)

(4) Explosives safety (identify threat and give distance or negative statement)

(5) Type of structural system and kind of materials to be used

(6) Fallout shelter statement

5. The submission for all disciplines are to be substantiated by an economic analysis of alternatives examined and brief statements of the rationale for the various selections.

EXHIBIT D.6

DEFINITIONS FOR SYSTEM STRUCTURE CATEGORIES
(Figure D.31)

. Aircraft systems refer to the complex of equipment, software, services, and facilities required to produce the capability of employing the air vehicles designed for flight in the atmosphere.

- Airframe. This column refers to the assembled structural and aerodynamic components of the air vehicle that support the engines and other subsystems essential to a particular mission. This element includes all effort relating to the integration and assembly of all equipments into the airframe to provide an air vehicle as a whole. It includes all equipment inherent to and nonseparable from the assembled structure, dynamic systems, rotor group, transmission, and other equipment homogeneous to the airframe. All effort directly related to the other elements are excluded.

- Power Plant. This column refers to the installed engines which provide power/thrust to propel the aircraft through all phases of powered flight. This element includes the engine as a power unit within itself, of reciprocating or turbo type suitable for integration with the airframe.

- Communications, Navigation/Guidance. This column refers to those equipments installed in the air vehicle for communication and identification purposes, and/or to perform the navigation/guidance function.

- Fire Control. This column refers to that equipment installed in the air vehicle which provides the intelligence necessary for ordnance delivery.

- Armament. This column refers to that equipment installed in or on the air vehicle to provide the firepower functions. If the Aircraft System has ordnance delivery equipment or auxiliary armament/ordnance delivery equipment the costs for those items will be included in this category and the column label annotated (i.e., by use of an *) to indicate that additional items have been included.

- Ammunition. This column refers to the ordnance materiels that produce the destructive effects of the Aircraft System. Ammunition to be costed with the Aircraft System normally will be the increase in the Authorized Acquisition Objective (AAO) resulting from the introduction of the system into the Army inventory.

- To Be Specified. This column is reserved for the cost analysts' use to highlight a subsystem of high management interest that would otherwise be submerged in one of the above hardware categories (columns).

- Peculiar Support Equipment. This column refers to those equipments required to maintain and care for the Aircraft System while not directly engaged in the performance of its mission, and which have application peculiar to the Aircraft System being analyzed.

- Common Support Equipment. This column refers to the equipment required to maintain and care for the Aircraft System while not directly engaged in the performance of its mission, and which are presently in the DOD inventory. It includes the acquisition of additional quantities of these equipments if caused by the introduction of the Aircraft System being analyzed.

- Other. This column refers to that equipment required by the Aircraft System but not elsewhere classified or which cannot be subdivided into the other major categories (columns).

• Missile systems refer to those ordnance delivery systems which employ unmanned self-propelled air/space vehicles to navigate, penetrate, and produce a desired effect on selected targets. The Missile System category includes systems designed for employment as weapons of air defense, land warfare, strategic bombardment, air and sea combat, and drones.

  - Airframe. This column refers to the assembled structural and aerodynamic components of the missile air vehicle that support subsystems essential to the mission. It includes integration and assembly. In those missile systems where the

propulsion assembly forms the structure for the missile, the cost of the propulsion unit will be included in this column.

- Propulsion. This column refers to the means for generating propelling forces on the missile.

- Missile Guidance and Control. This column refers to the means for generating or receiving guidance intelligence, conditioning and intelligence to produce signals, and generating appropriate control forces. Includes only on-the-missile equipment.

- Fire Control and Other Communications. This column refers to the means to enable targeting of missiles, launch decisions to be made, and to command launch. This column also refers to the means for distributing within the missile system, e.g., the communication subsystems for tactical and administrative message flow and ties between sensor, data processing, and launch and guidance control subsystems.

- Launcher. This column refers to the means to launch the missile.

- Missile Payload. This column refers to the means employed to produce the destructive effect on the target at the terminal point of flight.

- To Be Specified. This column is reserved for the cost analysts' use to highlight a subsystem of high management interest that would otherwise be submerged in one of the above listed hardware categories (columns).

- Peculiar Support Equipment. This column refers to those equipments required to maintain and care for the Missile System while not directly engaged in the performance of its mission, and which have application peculiar to the Missile System being analyzed.

- Common Support Equipment. This column refers to the equipment required to maintain and care for the Missile System while not directly engaged in the performance of its mission, and which are presently in the DOD inventory for support of other

systems. It includes the acquisition of additional quantities of these equipments if caused by the introduction of the Missile System being analyzed.

- Other. This column refers to that equipment required by the Missile System but not elsewhere classified or which cannot be subdivided into the other major categories (columns).

. Surface vehicle systems refer to the complex of equipment, softwares, services, and facilities required to develop and produce a vehicle system with the capability to navigate over the surface. This element also includes combat vehicles serving as armor, weapons platforms, reconnaissance vehicles, and amphibians.

- Hull/Turret/Suspension. This column refers to the vehicle primary structure, the structure and equipment installations producing the fighting compartment, and the means for generating tractive effort and adapting the vehicle to the irregularities of the surface.

- Power Package/Drive Train. This column refers to the means for generating power and delivering that power to the driving member.

- Communication Equipment. This column refers to the means provided within the system for implementation of command and control.

- Fire Control Equipment. This column refers to the equipment, installed in the vehicle, which provides the intelligence necessary for ordnance delivery such as launching or firing.

- Armament. This column refers to the means for Surface Vehicles to deliver fire on hostile targets.

- Ammunition. This column refers to the ordnance materiels that produce the destructive effects of the Surface Vehicle Systems. Ammunition to be costed with the Surface Vehicle System normally will be the increase in the AAO resulting from the introduction of the Surface Vehicle System into the Army inventory.

- To be Specified. This column is reserved for the cost analysts' use to highlight a subsystem of high management interest that would otherwise be submerged in one of the above listed hardware categories (columns).

- Peculiar Support Equipment. This column refers to those equipments required to maintain and care for the Surface Vehicle System while not directly engaged in the performance of its mission, and which have application peculiar to the Surface Vehicle System being analyzed.

- Common Support Equipment. This column refers to the equipment required to maintain and care for the Surface Vehicle System while not directly engaged in the performance of its mission and which are presently in the DOD inventory for support of other systems. It includes the acquisition of additional quantities of these equipments if caused by the introduction of the Surface Vehicle System being analyzed.

- Other. This column refers to the equipment required by the Surface Vehicle System but not elsewhere classified or which cannot be subdivided into the other major categories (columns).

. Electronic systems refer to the complex of equipment, software, services, and tasks required to produce the capability of electronics systems as represented by tactical data systems, fire control systems and communication systems. It includes the prime mission equipment, secondary/operational support equipment (shelters, trucks), training, peculiar/common support equipment associated with an operational electronics system.

- Automatic Data Processing Subsystem. This column refers to complex of hardware, software, and services, either contractor or in-house, required to produce the automatic data processing capability of the system. It includes the installed machine or group of interconnected machines consisting of input, storage, computing, control, and output devices which use circuitry in the main computing element to automatically perform arithmetic and/or logical operations by means of internally stored or externally controlled programmed instructions. This element includes, for example, a central processor, large-capacity

storage data channels, input/output, as well as the software of executive (compiler/source), diagnostic, maintenance, and operational programs.

- Data Display Subsystem. This column refers to the hardware, software, and services required to produce the data display portion of the electronic system. It includes the equipment/software necessary to provide visual presentation of processed data by means of specially designed electronic or electromechanical devices interconnected with the computing/processing subsystem, such as flat panel displays, projection screens, image data storage, and retrieval equipment. Although line printers and punch cards may display data, they are not usually categorized as displays but as output equipments.

- Communications Subsystem. This column refers to the hardware, software, and services necessary to provide the electronic system with a capability to receive and transmit messages or data from one person or place to another. It includes, for instance, radomes, antennae, transmitter, receiver, terminal equipment, internal facility trunking, modern cryptographic equipment, power supply, and interface equipment. It also includes internal communications such as public address, intercom, and leased-lines used for communication purposes.

- Sensor Subsystem. This column refers to the complex of hardware, software, and services required to produce the sensor portion of the electronic system. It includes those equipments which are used to extend man's natural senses, and equipment which detects and indicates terrain configuration, presence of military targets, and other natural and man-made objects by means of energy emitted or reflected by such targets or objects. The energy may be electromagnetic, including visible or invisible portions of the spectrum. This element includes radar, infrared, and sonar sensor system equipments.

- Auxiliary Equipment Subsystem. This column refers to the hardware, software, and services common to a number of previously defined subsystems, but are not integral to any of them. The element includes, for example, power generators, shelters, power distribution system, and security equipment.

Items that are an integral part of a specifically identified subsystem or pertain to the integration, assembly, and checkout of the total electronic system are included in the "other" column and excluded here.

- Payload/Ammo. Not Used.

- To Be Specified. This column is reserved for the cost analysts' use to highlight a subsystem of high management interest that would otherwise be submerged in one of the above hardware categories (columns).

- Peculiar Support Equipment. This column refers to those equipments required to maintain and care for the Electronic System while not directly engaged in the performance of its mission, and which have application peculiar to the Electronic System being analyzed.

- Common Support Equipment. This column refers to the equipment required to maintain and care for the Electronic System while not directly engaged in the performance of its mission, and which are presently in the DOD inventory for support of other systems. It includes the acquisition of additional quantities of these equipments if caused by the introduction of the Electronic System being analyzed.

- Other. This column refers to that equipment required by the Electronic System but not elsewhere classified or which cannot be subdivided into the other major categories (columns).

. Ordnance systems refer to the complex of equipment, software, services, and facilities required to develop and produce the capability for applying munitions to a target. This refers to both the munitions and the means of launching or firing the munitions.

- Carriage. This column refers to the primary structure which serves as a platform to accommodate other categories (columns), and provides mobility to the complete launch system. It is not a self-propelled vehicle (see Surface Vehicle Systems).

- Propulsion. Not used.

- Communications Equipment. This column refers to the equipment for the purpose of targeting rounds, launch decisions, and command launch. This column also refers to the equipment required for intracommunications between the elements of the ordnance system for tactical and administrative message flow between sensors, data processing, and launch control elements.

- Fire Control. This column refers to the equipment for controlling the direction, volume, and time of fire or release of munitions through the use of electrical, electronic, optical, or mechanical systems devices or aids.

- Launcher. This column refers to the structural device designed to support and hold munitions in position for firing or release.

- Complete Round. This column refers to all the components making up the ammunition necessary for firing one shot.

- To Be Specified. This column is reserved for the cost analysts' use to highlight a subsystem of high management interest that would otherwise be submerged in one of the above listed hardware categories (columns).

- Peculiar Support Equipment. This column refers to those equipments required to maintain and care for the Ordnance System while not directly engaged in the performance of its mission, and which have application peculiar to the Ordnance System being analyzed.

- Common Support Equipment. This column refers to the equipment required to maintain and care for the Ordnance System while not directly engaged in the performance of its mission, and which are presently in the DOD inventory for support of other systems. It includes the acquisition of additional quantities of these equipments if caused by the introduction of the Ordnance System being analyzed.

- Other. This column refers to that equipment required by the Ordnance System but not elsewhere classified or which cannot be subdivided into the other major categories (columns).

EXHIBIT D.7

THE COST ANALYSIS PROGRAM (ARMY)

OBJECTIVES THE OBJECTIVES OF THE COST ANALYSIS PROGRAM ARE:	POLICIES IT IS DEPARTMENT OF THE ARMY POLICY THAT:
1. To improve the allocation and management of Army resources at all levels through rigorous cost analysis of Army programs, materiel systems, forces, units and activities. (GOAL)	1. Cost analysis assist Army management in establishing and maintaining credibility with respect to materiel system cost estimates. A measure of credibility is the degree to which cost estimates can stand the test of time. 2. Cost analysis is an integral part of the Planning, Programming and Budgeting System (PPBS). 3. Cost analysis employ an approach and procedures oriented more to the macro rather than micro aspects of cost estimating. Cost analysis must demand completeness over preciseness and be more concerned with issue development than with detailed accounting procedures. *Simplification* in level of cost analysis detail is essential.
2. To develop and maintain cost analysis as an effective and efficient financial management tool at all levels. (TOOLS) (TOOLS)	4. Cost analysis be first and foremost a tool of management. This includes both the development of cost estimates and the analysis of these estimates. A cost analyst is a manager's advisor/consultant, answering the manager's question: "Is that estimate about right?" This manager/cost analyst relationship will exist at all levels in the hierarchy where decisions are made having significant economic impact. Cost consciousness will be assured through a check and balance process which identifies and/or anticipates for managers cost estimates which are unsupportable or otherwise unlikely to be sustained over time. 5. Cost analysis be timely and current in its role of assisting the decisionmaker. Scheduling of activities leading to decisions will explicitly include time for cost analysis to be performed. 6. Cost estimating and cost analysis will receive emphasis equal to that given requirements estimating and analysis in the weapons acquisition and force planning processes. Cost estimating and analysis are necessarily sequential activities to requirements estimating activities. Scheduling of acquisition process activities, including management reviews, and force planning activities will take into consideration and reflect the lead times required to accomplish, in a professional manner, the cost estimating and cost analysis function. 7. The Army's approach to cost analysis data bases, or data banks, be highly utilitarian. Analysts will gather cost data in support of pointed studies and research efforts. Data collected in support of specific efforts should be saved when it appears to have continuing usefulness. Determination of data to be saved and maintained and updated will be made on the basis of the professional judgment of cost analysis managers and practicing analysts. Cost analysis activities will maintain a current index to data banks/bases. Maximum exchange of cost data within the Army and between the Army and other Government agencies and non-Government agencies and non-Government organizations is encouraged, subject only to security and proprietary data restrictions.
3. To develop and maintain high levels of professionalism in cost analysis activities. (PEOPLE)	8. Cost analysis be particularly concerned with the cost estimate communications process. The cost analysis community will work for consistency, clarity, and candor in both oral and written presentations of cost data and evaluations. Simplicity and clarity in presentation will be observed. 9. Cost analysis be a professional endeavor adhering to a high code of professional practice and standards. Cost analysts must be objective, performing their service for managers by employing rigorous and disciplined analytical approaches and techniques. The profession must be particularly sensitive to the factors and/or conditions which lead to cost biasing and cost errors and able to relate such phenomena to cost estimates brought before management.

OBJECTIVES THE OBJECTIVES OF THE COST ANALYSIS PROGRAM ARE:	FUNCTIONS COST ANALYSIS FUNCTIONS ARE:
1. To improve the allocation and management of Army resources at all levels through rigorous cost analysis of Army programs, materiel systems, forces, units and activities. (GOAL)	1. To conduct cost analysis of existing or proposed weapon systems or materiel programs. 2. To conduct economic analysis of investment proposals and materiel acquisition programs. 3. To conduct cost analysis of existing or proposed force units or force structure. 4. To analyze cost of specific functional activities such as training, strategic mobility, logistical systems, and activation, operation and maintenance, opening and closing of installations and facilities.
2. To develop and maintain cost analysis as an effective and efficient financial management tool at all levels. (TOOLS) (TOOLS)	5. To develop cost estimates during all phases of the weapon system's life cycle in support of the decisionmaker's at the key management milestones and decision points. 6. To document cost estimates and analysis in ways permitting further analysis by higher headquarters and other organizations which may request such estimates and analysis, for example, the General Accounting Office and the Congressional Budget Office. 7. To issue guidance and direction to insure consistent preparation of cost estimates through the establishment and maintenance of uniform cost structures and formats and of standardized cost elements and definitions for weapon system and force structure cost analysis. 8. To establish and maintain cost tracks and to perform other similar functions associated with review and documentation of cost estimates. 9. To collect, maintain and provide weapon system research and development, investment and operating and support cost data required for cost analysis. 10. To collect, maintain and provide force unit and structure cost data required for cost analysis. 11. To perform research related to cost estimating methodology, models and techniques. 12. To insure that cost information is correct, inclusive and comparable in studies which evaluate system alternatives and to provide cost analysis assistance where required in these studies.
3. To develop and maintain high levels of professionalism in cost analysis activities. (PEOPLE)	13. To develop and improve the cost analysis discipline. 14. To maintain technical competence in keeping with advances in the state-of-the-art analysis. 15. To create and maintain a professional environment within which cost analysts are encouraged to conduct cost research, produce rigorous cost analysis, contribute to professional groups, and seek further training.

OBJECTIVES THE OBJECTIVES OF THE COST ANALYSIS PROGRAM ARE:	SUMMARY PROCEDURES COST PROCEDURES ARE THAT:
1. To improve the allocation and management of Army resources at all levels through rigorous cost analysis of Army programs, materiel systems, forces, units and activities. (GOAL)	1. Baseline and independent cost estimates will be prepared for all major weapon systems. These estimates need not agree with one another but their differences must be understood. Significant differences will be communicated to management through reports and/or briefings. 2. Independent and baseline cost estimates will include a range of costs to reflect the uncertainty associated with the point estimate. The range of costs predicts upper and lower bounds within which the actual cost is likely to fall. Prediction of the future costs should also reflect the sensitivity of projected costs to all critical assumptions. This should include factors such as the changes in performance characteristics, changes in configuration to meet performance requirements, schedule alterations, and alternative procurement strategies. 3. Funds will be programmed to support the acquisition and operation of weapon systems based on the estimate management decides is the most likely. This may result in programming an amount which is different from that specified in a contract or in a baseline cost estimate. 4. Independent materiel system parametric cost estimates will be prepared and documented in accordance with the Army R&D, Investment and Operating and Support Costing Guides. Materiel system cost estimates will be documented in accordance with their manner of preparation and the detail required by managers. 5. The Weapon System Cost Estimating Calendar will identify the type of cost analysis instrument to be employed at a given decision point, the responsible organization, and the due date. 6. Economic analysis will be performed according to procedures specified in AR 37-13.
2. To develop and maintain cost analysis as an effective and efficient financial management tool at all levels. (TOOLS) (TOOLS)	7. Cost analysts will be employed as cost estimators and evaluators in support of decisionmaking. The cost analyst provides the reviews and evaluations which bring meaning to financial management. 8. Baseline and independent cost estimates will be documented and updated to provide a complete cost estimating history for all major and selected non-major systems. All other cost estimates will be appropriately documented so as to record the cost history for management use. 9. Assumptions, ground rules and methodology used in developing baseline and independent cost estimates will be documented in sufficient detail to permit evaluation of each estimate and comparison between them to highlight significant differences for management review. 10. Costs developed in the various estimates should represent the total (full) requirements necessary to acquire and operate the weapon system being costed. The system characteristics, program parameters and study assumptions underpinning each cost estimate will be made explicit. As a minimum, the materiel system "Requirements Specification" will be completed and included in each cost estimate. 11. Force unit cost analysis will be employed to develop and maintain cost factors for use in the planning process. 12. The Force Cost Information System (FCIS) and associated cost factor handbooks are official sources of cost data for Army force planning studies/analysis/estimates. Force structure cost estimates developed by the Army Staff from the cost factors will be coordinated with COA for validation prior to use. 13. Force planning studies containing cost data by appropriation will be coordinated within Comptroller of the Army.
3. To develop and maintain high levels of professionalism in cost analysis activities. (PEOPLE)	14. Cost Analysis Career Field with its objectives and requirements will be issued through appropriate civilian personnel regulations. 15. Military personnel career programs in cost analysis will be in accordance with the Officer Personnel Management System (OPMS).

OBJECTIVES THE OBJECTIVES OF THE COST ANALYSIS PROGRAM ARE:	RESPONSIBILITIES THE COMPTROLLER OF THE ARMY WILL
1. To improve the allocation and management of Army resources at all levels through rigorous cost analysis of Army programs, materiel systems, forces, units and activities. (GOAL)	1. Provide overall functional guidance and direction for cost analysis and serve as focal point for the Army Cost Analysis Program. 2. Provide overall guidance to the major field commands for estimating and reporting independent system cost estimates. 3. Schedule and coordinate cost estimates for all major and selected non-major materiel system cost estimates. 4. Perform Independent Parametric Cost Estimates (IPCE) on a life cycle basis for selected ASARC systems. Selections are determined by COA in coordination with DCSRDA and DCSOPS. These will include all the Big 5 and such other systems as are deemed significantly important to require a completely independent estimate at the DA level. 5. Prepare for all other ASARC systems, for which parametric costing techniques are useful, an IPCE derived through joint participation with AMC personnel. 6. Validate cost inputs which are submitted by HQ AMC through HQDA for the Cost and Operational Effectiveness Analysis (COEA). 7. Recommend the Army position on cost to the ASARC. 8. Serve as a special member of the ASARC. 9. Provide costs of major forces and support level units as viewed by JCS and included in the joint plans such as the Joint Strategic Objective Plan (JSOP) and the Joint Force Memorandum (JFM). 10. Validate cost estimates of force structures and special force-oriented studies. 11. Provide overall guidance and direction to the major field commands for estimating and reporting baseline costs.
2. To develop and maintain cost analysis as an effective and efficient financial management tool at all levels. (TOOLS) (TOOLS)	12. Establish policy and procedures for the improvement of cost estimating methodology. Insure that a high level of quality in cost analysis is maintained. 13. Provide for the collection, storage, analysis and dissemination of force units/structure cost data applicable to the Army cost analysis program. 14. Establish policy and procedures for the collection, storage, analysis, synthesis and dissemination of materiel system cost data applicable to the Army Cost Analysis Program. 15. For selected ASARC systems formally document the baseline estimate and the IPCE by means of a comparative analysis so that they may be traced as the program progresses through the acquisition cycle. 16. Exercise Army General Staff responsibility for Selected Acquisition Reporting (SARs). 17. Provide and maintain cost handbooks for use in the force planning process.
3. To develop and maintain high levels of professionalism in cost analysis activities. (PEOPLE)	18. Assure the professional quality of field generated independent cost estimates. 19. Direct, coordinate and evaluate the Cost Analysis Career Program, including supervising and coordinating cost analysis training. 20. Monitor the operation of the cost analysis career referral system, particularly Army-wide referrals. 21. Establish, promulgate and maintain a code of professional standards for cost analysts.

OBJECTIVES THE OBJECTIVES OF THE COST ANALYSIS PROGRAM ARE:	RESPONSIBILITIES OTHER DA STAFF
1. To improve the allocation and management of Army resources at all levels through rigorous cost analysis of Army programs, materiel systems, forces, units and activities. (GOAL)	

1. The Deputy Chief of Staff for Operations and Plans (DCSOPS) will—

a. Designate which systems are to be considered major Army programs.

b. Assure that a current COEA is available at each ASARC milestone review.

c. Establish priorities for materiel requirements development, affordability determinations and procurement of equipment and user testing.

d. Provide data to COA for use in the costing/cost analysis of Army forces.

e. Develop the Army Force Program developing in detail the Army force structure approved by the Secretary of Defense for the current and budget years.

f. Serve as a regular member of the ASARC.

2. The Deputy Chief of Staff for Research Development and Acquisition (DCSRDA) will—

a. Examine proposed systems for affordability within priorities established by DCSOPS, in view of resources available or projected to be available to the Department of the Army.

b. Exercise General Staff responsibility for development and acquisition of the materiel systems in the appropriate requirements document, i.e., Operational Capability Objectives, Letter of Agreement, Required Operational Capability, Letter Requirement.

c. Coordinate all ASARC and DSARC reviews.

d. Formulate and execute the RDTE and procurement portions of Army programs and budgets.

e. Provide a capability for Army Staff Program Managers and MACOMS to influence the materiel development and acquisition process within the parameters of fiscal constraints and DCSOPS priorities and requirements.

f. Collect, store, analyze and disseminate budgetary data for research, development and acquisition-oriented appropriations required for cost analysis.

g. Serve as regular member of ASARC.

3. The Deputy Chief of Staff for Logistics (DCSLOG) will—

a. Establish logistic supportability/acceptability of major Army programs.

b. Serve as special member of ASARC.

4. The Chief of Engineers (COE) will collect, store, analyze and disseminate the following Army-wide cost data required for cost analysis:

a. Construction projects, construction materiel, construction techniques, and construction operations (except Military Construction Army National Guard).

b. Real property acquisition, management and disposal.

c. Real property maintenance activities.

d. Maps, map products and equipment peculiar to military mapping programs.

5. The Ballistic Missile Defense Program Manager will—

a. Collect, store, analyze, and disseminate cost information related to materiel systems, forces, and units in his area of responsibility.

b. Determine requirements for life cycle costs to be obtained from major Army commands to support cost effectiveness studies of weapon systems and units.

6. Chief of Army Reserves (CAR) will collect, store, analyze, and disseminate cost data on individual personnel support and force units in the US Army Reserves.

7. Chief, National Guard Bureau (CNGB) will collect, store, analyze and disseminate cost data on individual personnel support and force units in the US Army National Guard.

8. Heads of other DA Staff agencies will collect, store, analyze and disseminate cost data related to weapon and support systems, forces and units in their areas of responsibility required for cost analysis.

OBJECTIVES THE OBJECTIVES OF THE COST ANALYSIS PROGRAM ARE:	RESPONSIBILITIES MACOMS
1. To improve the allocation and management of Army resources at all levels through rigorous cost analysis of Army programs, materiel systems, forces, units and activities. (GOAL)	1. The Commanding General, US Army Materiel Command (AMC) will—

a. Perform integration of cost analysis in order to provide cost analysis of R&D, Investment and Operations of weapon systems and materiel items to HQDA, as required.

b. Develop and maintain cost information systems, to include data bases and cost models, as required.

c. Maintain and disseminate cost data and estimates related to depot maintenance of materiel and central supply activities within USAMC.

d. Prepare cost estimates of the operating costs of AMC organizations and installations.

e. Develop baseline estimates for materiel items.

f. Prepare and submit SAR's to HQDA.

g. Jointly participate with COA in preparation of independent estimates for selected materiel systems.

h. Prepare independent parametric cost estimates for selected materiel systems.

i. Provide cost estimates through HQDA of materiel for use by US Army Training and Doctrine Command (TRADOC) in support of cost-effectiveness studies (COA).

j. Have principal responsibility for the validation of non-major weapon system cost estimates.

k. Serve as regular member of ASARC.

l. Utilizing inputs from other major Army commands as required, prepare operating and support costs for weapon/support systems.

2. The Commanding General, US Army Training and Doctrine Command (TRADOC) will—

a. Collect, store, analyze and disseminate data for:
(1) Postulated Forces and Units.
(2) Individual training conducted in TRADOC schools and training centers.
(3) Base operations of all TRADOC installations.
(4) Central supply and maintenance activities within TRADOC installations.

b. Prepare and submit Cost and Operational Effectiveness Analysis (COEA) as required.

c. Serve as regular member of ASARC.

d. Provide necessary cost and related data to HQ AMC for preparation of operating and support costs for weapon/support systems, as required.

3. The Commanding General, US Army Forces Command (FORSCOM) will—

a. Collect, store, analyze and disseminate information on:
(1) Costs of field exercises within CONUS, except for Army components of Unified Commands.
(2) Unit training conducted in FORSCOM.
(3) Base operations of all FORSCOM installations.
(4) Central supply and maintenance activities within FORSCOM installations.
(5) Operating costs of CONUS based combat, combat support and combat service support units, activities and installations.
(6) Force unit and weapon system operating and support costs, below depot level, in the FORSCOM area of responsibility.

b. Provide necessary cost and related data to HQ AMC for preparation of operating and support costs for weapon/support systems as required.

4. The Commanding General, US Army Communications Command (USACC) will—

a. Collect, store, analyze and disseminate cost data on all assigned communications equipment, activities, installations and programs.

b. Prepare and submit Cost and Operational Effectiveness Analysis (COEA) as required.

5. The Commanding General, US Army Computer Systems Command, will collect, store, analyze and disseminate information related to Army multicommand automatic data processing systems

6. The Commanding General, US Army Security Agency (USASA) will—

a. Collect, store, analyze and disseminate cost information on all assigned equipments, activities, installations and programs.

b. Prepare and submit Cost and Effectiveness Analysis (COEA) as required.

c. Develop baseline cost estimates for assigned material items.

d. Validate assigned non-major weapon systems cost estimates.

e. Upon request, in coordination with ACSI, provide requirements and cost data.

7. The Commanding General, US Army Concepts Analysis Agency will—

a. Assist ODCSOPS in the analyses of force related issues to provide bases for materiel acquisition and implementation of Army materiel acquisition policy.

b. For designated materiel systems, review and evaluate trade-off determinations (TOD) and conduct trade-off analysis (TOA) and Cost and Effectiveness Analysis (COEA).

c. Serve as special member of ASARC.

8. The Commanding Generals of other major commands will collect, store, analyze, and disseminate cost information related to weapon and support systems, forces and units, in their area of responsibility, as required for cost analysis.

APPENDIX E

TRACKING OF

PROGRAMS - SHIPS - WEAPONS

In Support of the final report entitled, "A Study of Ship Acquisition Cost Estimating In The Naval Sea Systems Command"

Contract No. N00024-77-C-2013

INTERNATIONAL MARITIME ASSOCIATES, INC.
WASHINGTON, D.C.

OCTOBER 1977

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I. ESTIMATING PERFORMANCE OF THE NAVY

The study has thus far examined NAVSEA cost estimating from an organizational point of view. Additionally, to gain perspective on the strengths and weaknesses of NAVSEA, other organizations were examined and comparisons drawn.

What remains to round out the study is an assessment of the performance of NAVSEA and that is covered in this section. The estimation of all new or modified ships during FY 1975 and 1976 have been studied. Beyond that, studies of three representative ship programs and eight items of Government Furnished Material (GFM) are discussed. The objectives in these case studies were to determine the quality of estimating, first; then determine whether actions taken by others, either in program management or the political environment influence estimates and distort their original accuracy.

1. OVER THE LAST EIGHT YEARS, FUNDS REQUESTED FOR SHIPBUILDING PROGRAMS, WHICH TOTALLED $18 BILLION, HAVE GROWN TO $22 BILLION

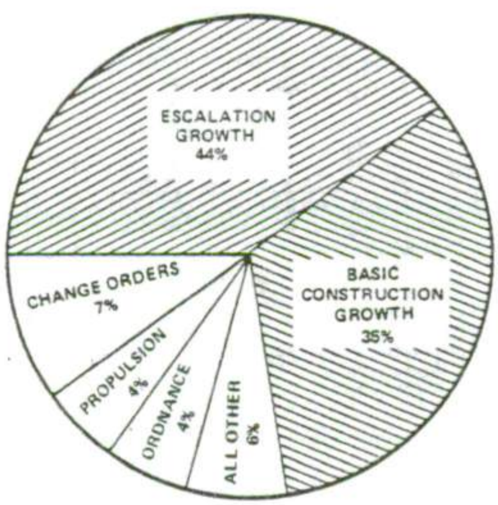
Between the FY 1970 and FY 1977 budgets, the Navy requested funding for 132 ships of 13 major types totalling some $18.8 billion. In late 1976, the Navy estimated that to maintain this program in a fully funded status, $22.2 billion would be required -- an 18 percent increase over the years totalling $3.4 billion.

The 18 percent may be somewhat misleading, however, since cost growth in 1976 and 1977 is minimal, if any. These programs have just started construction or in some cases are in the bidding process and, therefore, tend to distort cost growth if recent history repeats itself.

As is pointed out in Chapter I, the largest cost increase by far is growth in unanticipated escalation and basic construction. Very weak third, fourth and fifth causes are unanticipated growth in change orders, ordnance and propulsion. Figure E.1 following shows this.

FIGURE E.1

ELEMENTS OF TOTAL PROGRAM COST GROWTH



In terms of dollar values, the following relate to the percentages shown in the figure:

- Escalation $1,500,000,000
- Basic Construction 1,200,000,000
- Change Orders 238,000,000
- Propulsion 136,000,000
- Ordnance 136,000,000
- All Other 204,000,000

It is clear that the Navy shared with many organizations -- public and private -- the problem of unanticipated escalation. Over $1 billion of unanticipated inflation can be shown to have occurred on the high dollar value programs (SSN, TRIDENT and FFG) constructing during recent years. This problem is further compounded by government-directed escalation rates which were often unrealistic. An additional factor is the difference in escalation and inflation-related factors between industries where shipbuilding, for example, seems to have been affected to a greater degree than other industries.

It is another matter, however, with regard to overruns in basic construction, ordnance and electronics. It is the responsibility of the Navy to be equipped to make reasonable predictions in these areas. As a procurement "giant," knowledge of the shipbuilding industry, expertise in product engineering, and experience in project management are areas in which the Navy should excel. Case studies and estimate tracking, however, have shown this

to be open to question.

2. NAVSEA BASIC CONSTRUCTION ESTIMATES -- WHEN COMPARED WITH CONTRACT AWARD AND END COST FIGURES -- SHOW WIDE VARIANCES

The reasons for cost growth in basic construction are not highly visible. It can be caused by such varied factors as inflation, design development problems, poor estimates, lowered productivity, fluctuating overhead, market changes, building period misestimates, etc. It is this portion of the end cost estimate that depends most upon the skill and capability of the NAVSEA Cost Estimating Group in that basic construction cost can vary from 30 to 70 percent of the end cost of a ship. It is the portion of the end cost that is calculated solely by NAVSEA 01G and can usually be compared directly to the shipyard contract price, i.e., target price. Thus, the comparison of the basic construction figure to the contract price can demonstrate, to a large degree, performance on a specific ship case.

Table E.1 shows NAVSEA 01G estimating performance for FY 1975 and FY 1976 (excluding program awards based on option agreements of prior year procurements). In FY 1975, NAVSEA estimates supplied to Congress were 35 percent below the contract or low bid price. In FY 1976, their figure was 12 percent lower than contracts awarded.

TABLE E.1

BASIC CONSTRUCTION ESTIMATES

Fiscal Year	Ship/Class	Original Budget Figure (000)	No.	Original Estimate Date	Contract Award Price (000)	Contract Award Date	Dollar Difference (000)	Percentage Increase	Time Between Budget Est. & Award (in months)
75	SSN 688	254,400	3	7/73	309,488	8/75	55,088	21.7	25
75	FFG 7	148,650*	3	8/74	193,205	2/76	44,555	30.0	18
75	AD	90,400	1	3/73	162,660	12/75	72,260	79.9	33
75	ARDM	16,350	1	3/73	24,427	10/75	8,077	49.4	31
Total		509,800			689,780		179,980	35.3	
76	SSN 688	188,500	2	7/74	189,970	2/76	1,470	00.08	19
76	FFG 7	251,710	6	1/75	320,699	2/76	68,989	27.4	13
76	AD 42	134,700	1	1/74	143,511	3/76	8,811	6.5	26
76	AO	147,420	2	8/75	153,050	8/76	5,630	3.8	12
Total		722,330			807,230		84,900	11.8	

* The original budget figure is $110,940,000 made in June 1974 for three ships based on an average unit cost of a seven ship buy. The figure shown is a revised estimate made in August 1974 for a three ship buy which reflects the increase in cost per ship for a reduced number of ships plus changes, etc.

In order to determine why basic construction experiences such growth, the following cases were examined in detail for the FY 1975 program:

- SSN 688 class -- 3 Submarines
- FFG 7 class -- 3 Frigates
- AD 41 -- 1 Destroyer Tender
- ARDM 4 -- 1 Floating Dry Dock

(1) <u>The SSN 711, 712 And 713 Budgeted In FY 1975, Although Repeat Ships, Were Underestimated By 22 Percent</u>

The SSN 711, 712 and 713 are the 24th, 25th and 26th ships of the SSN 688 Class submarines and were awarded to Newport News on August 1, 1975. The SSN 688, the first of the class, was awarded to the same builder over four years earlier on January 8, 1971. Subsequent to January 1971, eight ships had been awarded to Newport News and 18 to General Dynamics - Electric Boat Division.

The basic construction cost estimate for the FY 1975 ships made on July 10, 1973 was $254,400,000 for the three ships or about $84,800,000 each. The total end cost for the program of three ships was estimated to be $580,500,000. The most recent budget document, dated June 1, 1977, estimates basic construction at $309,493,000 for the three ships or $103,164,000 each based on the contract price. The increase in basic construction from July 1973 to August 1975 is approximately 22 percent.

The initial estimate prepared for the FY 1975 budget made in July 1973 was based on General Dynamics - Electric Boat bid data of November 1970, adjusted for construction learning and inflation. The estimate considered only three large aggregations of cost -- engineering man-hours, production man-hours, and material. All the notations on the estimating back-up sheets indicate that the $84.8 million is for each of five ships, regardless of the fact that only three were in the budget.

The revised estimate of $103,164,000 was based on Newport News bid data of January 30, 1975. The major elements of cost growth related to the basic construction estimate was labor man-hours and material. The material increased by 47 percent and labor and overhead cost was 20 percent greater than the NAVSEA estimate.

On hindsight, this overrun in material could be expected since it bridged the years of highest inflation. In fact, between the time the estimate was made in mid-1973 and the materials were purchased in 1975 and 1976, material costs increased by as much as 100 percent according to the NAVSEA index. It is unlikely that this aberration would have been foreseen by anyone.

After granting this exception, however, it must be noted that the procedure used in estimate preparation would in most cases tend

to provide less than adequate data. The guide to material costs utilized in mid-1973 was bid data from late 1970. Data from a time period about four years prior to the material purchase period was used when return data from other partially completed SSN 688 class ships was available. This four year difference could have been reduced to two years and in almost all cases (except 1974 and 1975) material trends would have been recognized.

TABLE E.2

SUMMARY OF SSN COST GROWTH ON
FY 1975 BUDGET
(3 - SSN 688 Class)

Breakdown of Estimate	Orig. Est. Approved By Congress (000)	4/77 Current Estimate (000)	Estimate Change (000)
Plan Costs	12,000	15,000	3,000
Basic Construction	254,400	309,493	55,093
Change Orders	21,000	24,707	3,707
Electronics	55,410	54,900	(510)
Propulsion Equipment	105,900	105,900	-
Hull, Mechanical, Electrical	55,707	51,000	(4,707)
Other Costs	5,400	3,600	(1,800)
Ordnance	8,550	9,000	450
Future Characteristics Change	6,000	5,100	(900)
Escalation Budgeted	33,885	160,200	126,315
Escalation Earned	-	-	-
Project Managers Growth Factor	22,248	-	(22,248)
Total Ship Estimate (3 ships)	580,500	738,900	158,400

The above table shows two primary areas of growth -- basic construction (21.7 percent), escalation (372 percent) which along

with other increases and decreases makes for an overall increase for the total ship of 27 percent.

(2) The FFG 8, 9 And 10, Which Are First Production Hulls, Have Thus Far Experienced A 30 Percent Cost Growth

The FFG ships in the FY 1975 program are the FFG 8, 9 and 10, and were awarded to Todd Shipbuilding (both San Pedro and Seattle yards) and Bath Iron Works on February 27, 1976, for a total $165,665,753 target price including profit. The original basic construction budget estimate is recorded on the budget document as $110,940,000. This reflects the proration made by Congress when the program was reduced from seven ships to three. The records of SEA 01G show that their basic construction cost estimate for three ships at that time to be $129,140,000. The $165,665,753 does not include the gas turbine propulsion system and generators as does the $129,140,000 because it was decided in the period between estimates and contract award to procure this equipment as Government Furnished Equipment in lieu of CFM. A comparable figure of $193,205,753 is then obtained by adding $27,540,000 for this equipment to the $165,665,753 figure.

According to this record of cost estimating, the Navy underestimated the FY 75 FFG program by 52 percent.

Records in SEA 01G indicate that the back-up for the contract price of the FFG 8 exceed the corresponding Navy estimates as follows:

- Labor hours 37%
- Overhead 73%
- Material 47%
- Profit 77%
- Total Basic Ship 52%

TABLE E.3

1977 NAVY BUDGET ESTIMATES FOR
FY 75 FFG FOLLOW SHIPS (3)
(Dollars in Thousands)

Breakdown of Estimate	6/74 Orig.Est. Approved By Congress	8/74 NAVSEA Revised Estimate	4/77 Current Estimate	6/74 Estimate Change	8/74 Estimate Change
Plan Costs	1,020	2,580	2,580	1,560	-
Basic Construction	110,940	148,650	164,680	53,740	16,030
Change Orders	3,360	3,720	20,900	17,540	17,180
Electronics	13,110	16,300	30,680	17,570	12,380
Propulsion Equipment	-	-	27,540	27,540	27,540
Hull, Mechanical, Electrical	4,170	6,180	8,740	4,570	2,560
Other Costs	330	840	1,180	850	340
Ordnance	37,110	60,870	75,730	38,620	14,860
Future Characteristics Changes	-	-	-	-	-
Escalation Budgeted	11,100	44,500	55,510	44,410	11,010
Escalation Earned	-	-	3,000	3,000	3,000
Project Managers Growth Factor	4,860	9,660	13,060	8,200	3,400
Total Ship Estimate (3 ships)	186,000	295,300	403,600	217,600	101,300

The conclusion that is drawn from the review is that official budget documents show an overrun for the total ship estimate (three ships) to be 117 percent or 37 percent depending on the base used.

It would appear based on documentation made available, that the underestimate for basic construction was about 52 percent.

This basic construction estimate of $129,140,000 (three ships) was revised substantially in August 1977, two months after the seven ship estimate was developed, which increased the cost to $148,650,000.

This new estimate includes what is described as

- "Reflects experience learned on lead FFG"
- "Includes additional (4th) SSDG*"

The cost growth from this revised basic construction estimate to the current estimate of $164,680,000 is approximately 11 percent.

(3) <u>The AD 41, Which Is A Repeat Of The AD 37 and 38, Is Experiencing A Current Overrun Of 80.5 Percent</u>

There have been only two Destroyer Tenders (ADs) built since World War II. The AD 37 and AD 38 were built in the Puget Sound Naval Shipyard and delivered in September 1967 and August 1968. The AD 41 is the third of a new class destroyer tender with the capability to service nuclear ships. The original budget estimate to Congress, prepared October 11, 1971 for the FY 1973 budget was based on return costs of the first two ships -- the AD 37 and 38. It was

estimated that the basic construction cost for a third AD in the FY 1973 SCN program would be $81.9 million if built in a naval shipyard and $64.6 million if built in a commerical shipyard.

The FY 1973 estimate took into account Headquarters Modification Requests and other changes not included in the AD 37 and 38 design such as an accommodation change from a Type Command Ship to a Flotilla Command Ship. For all changes, however, the light ship weight increased only 72 tons to the current estimate of 13,271 Light Ship Tons.

The AD was dropped from the FY 1973 program due to fiscal constraints but reappeared in the FY 1975 program. SEA 01G re-estimated the AD 41 on March 23, 1973 for the FY 1975 program on the basis of bids received on similar ships -- the AS 39 and 40 received from Litton and General Dynamics in June 1972. Using the nine group breakdown from these bids, the basic construction costs in FY 1975 were re-estimated at $90.4 million. Table E.4 following details the estimate and subsequent cost history.

TABLE E.4

AD 41 ESTIMATE HISTORY

	FY 73 Budget (10/71)	FY 75 Budget (3/73)	08/74 SCA	04/75 OSD Approved	Budget Estimate (6/76)*
Man-hours**	3,844	3,900	5,838	5,838	6,342
Labor Rate (direct & overhead)	$8.26	$10.24	$10.04	$10.61	$11.74
Labor Cost**	$31,738	$ 39,916	$ 58,610	$ 61,967	$ 74,447
Material Cost**	$26,998	$ 41,255	$ 51,750	$ 54,015	$ 70,953
Profit Rate	10%	11%	11%	12%	11.87%
Basic Construction**	$64,610	$ 90,400	$122,500	$129,900	$162,737
Contract Escalation**	$ 3,576	$ 5,460	$ 38,500	$ 40,054	$ 44,375
Change Orders Allowance**	$ 3,000	$ 4,525	$ 6,100	$ 6,500	$ 22,300
GFE**	$10,160	$ 9,202	$ 13,958	$ 17,303	$ 8,700
Other**	$ 5,554	$ 7,113	$ 6,442	$ 6,943	$ 8,188
End Cost**	$86,900	$116,700	$187,500	$200,700	$246,300
Estimate Classification	"C"	"C"			

* Based on NASSCO Bid of December 1975

** Expressed in thousands

In August 1974, the AD basic construction cost was re-estimated in a Ship Cost Adjustment review and increased to $122,500,000 with an associated end cost of $187,500,000. This estimate was based upon a re-bid of the AS 39 and 40 by Lockheed in November 1973. Lockheed was the sole bidder and was given a cost plus fixed fee contract for the AS 39 and 40 in November 1974.

The AD 41 estimate was again revised on March 31, 1975 to reflect a three month delay in award which increased the end cost to \$200,700,000 from \$187,500,000. Finally, the last estimate shows \$162,737,000 for basic construction and \$246,300,000 for end cost based on the NASSCO bid and subsequent award of the AD 41 on December 15, 1975. The basic construction cost has subsequently grown to \$171,500,000 as shown on the latest Ship Cost Adjustment reports.

The cost growth in basic construction between the March 1973 estimate of \$90.4 million and the bid estimate of \$162,737,000 is summarized in Tables E.5 and E.6.

TABLE E.5

ESTIMATED VERSUS ACTUAL COST GROWTH
BY MAJOR CATEGORY
AD 41

	Percent Growth
Light Ship Weight	1.4
Labor and Engineering Man-hours	62.5
Labor Costs	118.5
Material Costs	75.5
Overhead Costs	74.5
Profit	95.5
Basic Construction Cost	80.0

Table E.5 shows the percent growth that took place between March 1973 and June 1976 by major cost category. The significance of this comparison is the remarkable consistency of miscalculation of all major estimating categories when the physical changes were minor -- increasing the ship's weight by only 1.4 percent. This may have been due to a rapid change in productivity and material costs. Table E.6 below shows the same cost differences in the form of the nine cost group breakdown.

TABLE E.6

ESTIMATED VERSUS ACTUAL COST GROWTH
BY NINE COST GROUPS
AD 41

	------ Growth Percentage	-----------	
	Man-hours	Material *	Ship Changes **
Hull Structure	53.5	48.0	-
Propulsion Plant	25.7	113.0	-
Electric Plant	-25.5	6.0	-
Command and Surveillance	24.0	111.0	-20.0
Auxiliary Systems	63.8	102.0	+3.0
Outfit and Furnishings	54.8	94.0	+8.0
Armament	38.1	-28.0	-50.0
Integration Engineering	142.3	-56.3	-
Ship Assembly and Support	74.2	233.0	-

* Dollars
** Weights

According to the Navy Material Index, material prices grew 55 percent between March 1973 and December 1975. The material inflation growth shown in Table E.5 (by comparing the March 1973 estimate to the current estimate) is 75.5 percent. This may be due in some degree to the NASSCO practice of extensive subcontracting. The difference in labor hours of 62.5 percent then becomes even more difficult to explain when the characteristics of the ship remained essentially unchanged. In fact, the weight growth was only 1.4 percent. This is either the result of bad estimating or a rapid deterioration of productivity that could not be predicted. The succeeding Table E.6 shows variations in labor estimates among the nine cost groups from -25.5 percent to 142.3 percent, a range of 168 percent.

From records in SEA 01G, it would appear that no attempt has been made to record the results of the contract negotiation to reconcile these wide differences as a protection against similar discrepancies in the future. Possible explanations of these differences may be:

- The effect of a seller's market where the shipbuilders were willing to take Navy work only if they had sufficient man-hours to cover all possible contingencies such as:
  - Quality control and rework
  - Hidden specifications requirements

- Disruption caused by changes or late GFM
- Unexpected engineering documentation
- Compliance with DOD INST 7000.2
- Productivity considerations

. The AS bids of June 1972 by Ingalls and General Dynamics may have been very low and SEA 01G reflected the data in the AD 41 estimates.

. The NASSCO bid may have been high due to a backlog of commercial work and due to its man-hour overrun on the AOR 7. SEA 01G, again, did not have sufficient data or insight to detect it.

. Since Puget Sound Naval Shipyard delivered a similar ship in 1967 with considerably fewer man-hours expended, something dramatic happened to productivity and/or it had become increasingly difficult to work with the Navy.

NAVSEA had demonstrated in this instance that they have the capability to extrapolate experience from similar ships to derive a cost estimate, but in budget preparation during that period, the group did not detect the impact of rapid changes in productivity, market conditions and inflation.

NAVSEA was and is not prepared to question a shipyard estimate by individual cost group which deals with man-hour and material details. This is due to a lack of readily retrievable current bid and return cost data. This type of information is needed to detect productivity and other general trends -- which is difficult under any conditions. Currently NAVSEA is increasing labor

estimates by 15 percent to reflect changes in productivity.

(4) The ARDM 4 Has Experienced A Cost Growth Of 52.4 Percent

The ARDM 4 is the first drydock to be built by the Navy since World War II. The basic construction estimate dated March 13, 1973 was $16,350,000 and carried a "D" classification. This estimate was included in the FY 1975 budget submission to Congress. Two years later, on February 14, 1975, a contract estimate was prepared prior to receipt of bids and the cost was re-estimated at $18,640,000 on an adjusted price basis which took into account unanticipated inflation that took place from 1973 to 1975. On July 29, 1975 bids were received from a single bidder -- Bethlehem Steel Company -- for $24,996,000 on an adjusted price basis (i.e., to be adjusted for labor and material escalation during contract). A reconciliation was attempted to account for the difference between the Navy estimate and Bethlehem's. This review led to a voluntary price reduction of $569,000 by Bethlehem and an award was then made on October 23, 1975 for $24,427,000.

A comparison of the end cost breakdown prepared for the FY 1975 budget on March 13, 1973 and the most recent estimate of June 1977 is shown in Table E.7.

TABLE E.7

ARDM 4 COST GROWTH
(Dollars in Thousands)

	Budget Estimate 3/13/73	Estimate as of 6/77	Percent Growth
Construction Plans	500	-	-
Basic Construction	16,350	24,300	48.6
Basic Changes	1,650	2,000	21.2
Future Delivery Charges	800	-	-
Escalation Budgeted	-	2,600	-
Other Costs	440	500	13.6
Grand Total	19,740	29,400	48.9

The $16,350,000 estimate of March 13, 1973 was classified by the estimator as "D" quality and, in doing so, indicated that it should not be considered budget quality. Nevertheless, it was used for the budget submission and the record does not provide further explanation.

As can be seen, the major contributor to cost growth is in the estimate for basic construction (49 percent). One cause of this difference is in the area of labor rate. It is shown in Table E.8 that the quantity of labor was 22 percent less than the NAVSEA estimate and further that Bethlehem used $9.44 per hour compared to the Navy's $5.40 per hour. Bethlehem presented back-up that finally convinced the Navy that this rate was reasonable for the Bethlehem shipyard.

The breakdown of percent differences in the basic construction estimate is shown in the following table. It is a comparison of the Navy man-hours and material estimate of March 13, 1973 and the accepted Bethlehem bid dated July 29, 1975.

TABLE E.8

COMPARISON OF ARDM 4 ESTIMATE VERSUS BID

		Percentage Growth	
		Labor Man-hours	Material
100	Hull structure	- 57	+ 12
200	Propulsion Plant	-	-
300	Electric Plant	+ 37	+ 154
400	Command & Surveillance	- 45	+ 171
500	Auxiliary Systems	- 38	+ 159
600	Outfit and Furnishings	- 26	+ 144
700	Armament	-	-
800	Integration Engineering	- 41	+ 1,650
900	Ship Assembly/Support Services	+ 140	+ 382
	TOTAL	- 22	+ 162

The record does not indicate that the drydock design changed in the intervening time so that when comparisons of estimated man-hours and material costs are examined, differences are so large that one can conclude that either the Navy greatly under-estimated the job or Bethlehem had greatly over-priced it. The ship is now under construction on a fixed price contract, hence, it will be some time before the reason can be known. In any event, since the Navy did

accept the Bethlehem bid, the overrun is real and as far as budgeting is concerned, it was underestimated.

Bethlehem did submit a detailed estimate to back-up their bid but since NAVSEA uses only a nine group breakdown in their estimating, a sole source award was considered without benefit of knowing in detail why man-hour and material cost differences were so large. SEA 01G subsequently examined the Bethlehem bid back-up, met with Bethlehem officials, and decided that the price was reasonable. Upon this advice, the contracting officer negotiated the contract.

In retrospect, several considerations should be kept in mind.

- Market conditions were such that Bethlehem was the sole bidder. If the market had been such that several bids had been received, it would not have been unreasonable to expect a low bid up to 25 percent less than that submitted by Bethlehem.

- NAVSEA made its budget estimate 31 months prior to award. During this period, the NAVSEA "Cost Group" Index increased 60 percent, which is twice what might have been reasonably expected in 1973.

It could be concluded that had the market conditions of 1973 continued into 1975 and had material inflation remained within reasonable limits, the Navy's March 31, 1973 estimate of

$16,350,000 would still have been on the low side -- but not as seriously as it seems now.

(5) SEA 01G Estimating Performance On Ships Contracted For In The FY 1975-1976 Budget Averaged 30 Percent Below The Contract Price

Table E.9 shows NAVSEA estimating performance in relation to design status (i.e., new or repeat), time lapse between the budget estimate and award, and the difference in estimated values used by Navy and low bidder for labor hours, material dollars and overhead cost.

In FYs 1975 and 1976, the only new designs were the ARDM 4 and the AO. The remainder consists of repeat designs with no changes in design which would affect price after the initial estimate to any great extent.

With regard to labor hours, the Navy estimates were substantially less than the bidder except for the ARDM 4 and the SSN 688. In the case of the ARDM 4, the labor rate used by the bidder was 75 percent higher than that used by the Navy; however, the number of man-hours used by the bidder was 22 percent less. Overhead estimates (in two cases) were about 74 percent low. The most consistent difference is with respect to material costs.

TABLE E.9

BASIC CONSTRUCTION COST GROWTH
FY 1975 and FY 1976

Fiscal Year	Program	Basic Construction Cost Growth (percent)	Design Status	Time Between Budget Est. and Contract Award (months)	Increase in Basic Estimate Between Budget and Award: Labor Hrs. (percent)	Material (percent)	Overhead (percent)
1975	SSN 688	22.0	Repeat	25	1/	47.0	1/
1975	FFG 7	52.0	Repeat	18	37.0	47.0	73.0 2/
1975	AD 41	80.5	Repeat	33	62.5	75.5	74.5
1975	ARDM	48.0	New	31	(22.0)	162.0	(10.0)
1976	SSN 688	0.1	Repeat	19	*	*	*
1976	FFG 7	27.4	Repeat	13	*	*	*
1976	AD 42	6.5	Repeat	22	*	*	*
1976	AO	3.8	New	12	*	*	*

* Not analyzed.

1/ Overrun for labor and overhead dollars combined is 20 percent.

2/ No documentation available to make this determination.

The effort to quantify the estimating capability of NAVSEA was complicated by the fact that the continuity and quality of estimate records in NAVSEA over the 33 month time span between the budget and time of award, e.g., AD estimate for FY 1975, are completely inadequate. This was demonstrated by the inordinate amount of time spent by study staff and NAVSEA personnel to track this relatively small sample of estimating performance. A more comprehensive analysis of performance was precluded by inadequate estimate documentation. The limited examples included, however, do represent almost all of NAVSEA's estimating activities for the 1975 program.

What has been found is that the Navy failed to recognize, in the 1972 through 1974 time frame, the magnitude of changes taking place which were changing the character of the industry.

- Increasing labor costs
- Skyrocketing material costs
- A rapid drop in labor productivity
- Rapid growth in overhead cost
- Effects of a seller market in the industry

This is not to forget the difficulties in predicting prices and costs two to three years in advance of contract award even under the most favorable circumstances. Navy estimators have even

greater difficulty, however, because of late program changes and poor product definition. In addition, the allowances by OSD for future inflation have proved in the past to be inadequate.

Considering this environment, the Navy should have a particularly strong and capable Cost Estimating and Analysis group to cope with these conditions -- perhaps an elite group might be the term.

This study of the FY 1975-1976 program has brought to light a number of problems that can be noted.

- Cost estimates were calculated in too aggregated a manner (nine cost groups). Greater accuracy and familiarity with design features and weapons systems could be expected if estimates were to reflect available detail of the design development.

- Data banks were inadequate and not in a form that facilitates rapid retrieval of data in usable form. Neither do they contain the mass of pertinent cost data that is available within the Navy or properly available to it.

- Estimate documentation setting forth the rationale behind an estimate, data source, purpose, design data, etc., in most cases, was incomplete and/or nonexistent.

- No systematic effort was made to monitor and analyze return costs in on-going programs to keep Cost Estimating Relationships up-to-date or to determine current productivity trends.

- The estimating and cost analysis staff had very limited contact with shipyard and industry counterparts. As a result they did not have an opportunity to keep abreast of current developments and trends until it was too late.

- The cost analysis and estimating staff is a dedicated group having implemented many previous study recommendations, but on the whole, has been insufficient in numbers, experience, training and budget resources to adequately estimate complex Navy ships.

- In addition to the lack of estimate documentation, record keeping in the Division was poor. No records were kept, for example, of where time is spent on the numerous functions assigned to the Division.

- Supervision was insufficient in that all supervisors through GS 15 were working supervisors and often could not give adequate guidance to subordinates or give their work adequate review.

II. THE SELECTION PROCESS AND TRACKING PROCEDURES

As part of the work effort a sampling of ship and GFM acquisitions were to be examined to determine their cost history and estimate accuracy. This section reports how the selection process was conducted and describes the tracking procedures.

1. A NUMBER OF SHIP AND GFM CASES WERE SELECTED FOR MORE IN-DEPTH STUDY TO PROVIDE FURTHER CLUES AS TO THE CAUSES OF COST GROWTH

The ship cases selected demonstrated cost growth between the Congressional budget and estimated (or actual) end cost of

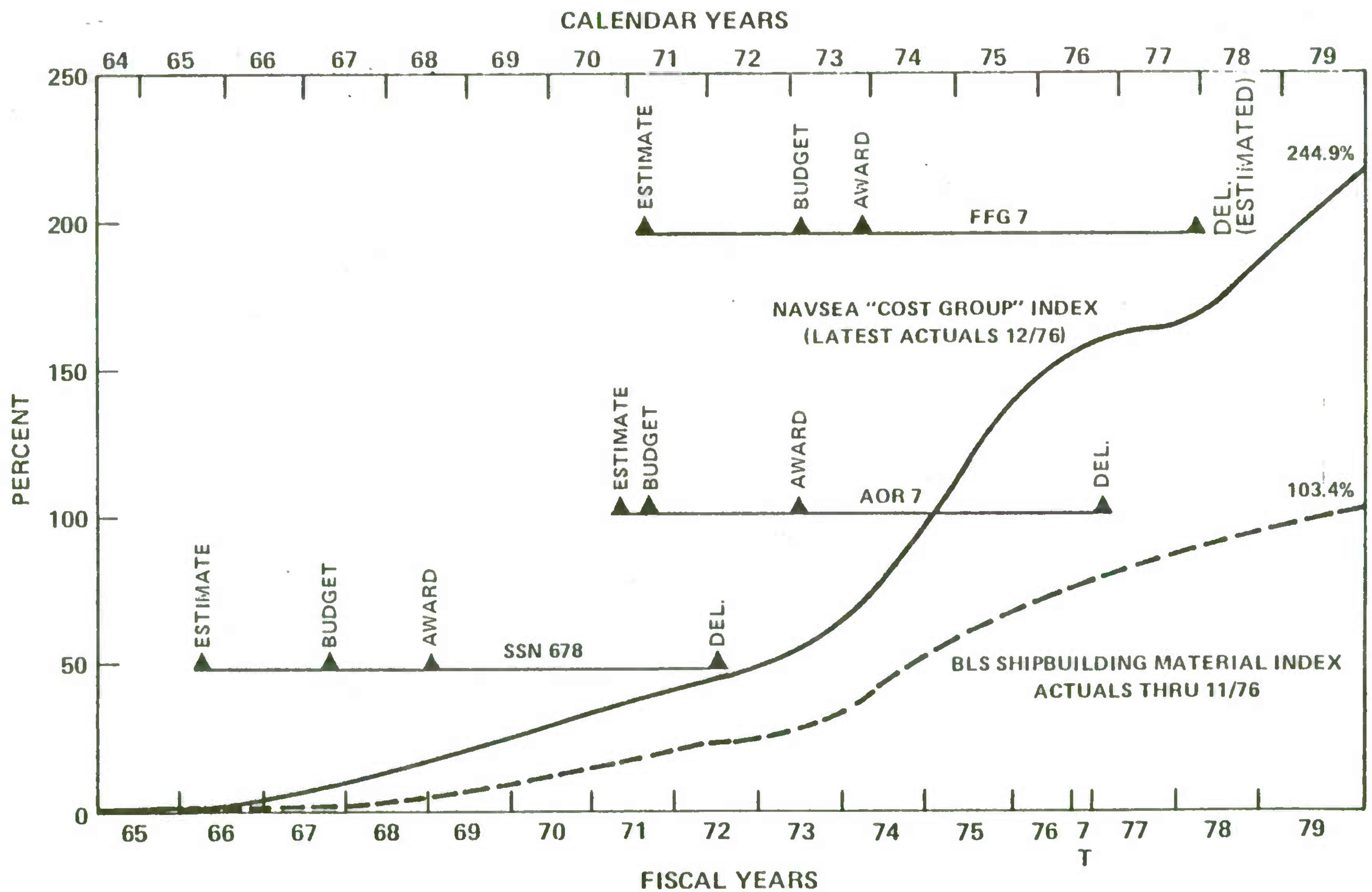
- 53 percent for the AOR 7
- 20 percent for the SSN 678
- 41 percent for the FFG 7

These ships are vastly different in terms of program development status, engineering sophistication, economic and market influences during building periods and priority within the shipbuilding program.

To illustrate one of these differences -- economic influences during the building periods -- Figure E.2 shows the material and labor inflation indices between the years 1965 and 1977. Superimposed on these indices are the development periods for each of the three ships. The difference in economic environment is obvious.

FIGURE E.2

MATERIAL COST GROWTH AND KEY PROGRAM DATES FOR SHIP CASES



Before describing the ship programs examined, however, a brief section on the method of selecting the ship and GFM items to be tracked follows.

2. A SYSTEM WAS DEVISED TO SELECT SHIPS IN A RATIONAL WAY

The system followed involved successive elimination of ship classes and, then, specific ships on the basis that those retained for consideration possessed a greater number of the features that would involve the full scope of the estimating process.

(1) The Program Years Studied Were Limited To Fiscal Years 1970 Through 1977 To Provide Relevancy To The Current Situation

The review included 108 ships of 12 different types in the following five Budget Activities: 1) Ballistic Missile Ships; 2) Other Warships; 3) Amphibious Ships; 4) Mine Warfare Patrol; and 5) Auxiliaries and Craft. Programs that were not included are those that were considered as being not representative of typical ship construction. These were the SSBN POSEIDON conversions wherein major sections of the ships were not involved. Also, four T-ATF tugs and smaller craft were not considered because of their relatively small impact in the SCN appropriation.

The following listing identifies the ship classes that were reviewed. For information purposes, a brief description and statement of the mission of these ship classes is contained in Exhibit E.1 which is found on page E-318.

- 31 SSN (688 class) Nuclear Submarines, which commenced with an appropriation for the construction of three ships in FY 1970 and continued with three ships or more each fiscal year thereafter.

- 5 SSBN (TRIDENT) Fleet Ballistic Missile Submarines (nuclear propulsion), which commenced with a single ship in FY 1974 and are continuing at one or two per year.

- 30 DD (963 class) Destroyers, which commenced with an appropriation to construct three ships in FY 1970 and continued with an appropriation for six or seven through FY 1975.

- 18 FFG (7 class) Guided Missile Frigates, which commenced with a single PF (the original designation) in FY 1973 and are continuing at varying rates since FY 1975.

- 2 CVN (68 class) Aircraft Carriers (nuclear propulsion), one of which was authorized in FY 1970, the other in FY 1974.

- 4 CGN (38 class) Guided Missile Cruisers (nuclear propulsion), one of which commenced in FY 1970 with one each in 1971, 1972, and 1975.

- 4 LHA (1 class) General Purpose Amphibious Assault Ships. This program commenced with authorization of a single ship in FY 1969 (which is not included herein) and two each in 1970 and 1971.

- 3 AD (41 class) Destroyer Tenders, which commenced in FY 1975 and continued with one each in 1976 and 1977.
- 3 AS (39 class) Submarine Tenders, which commenced with on ship in FY 1972, followed with one in 1973 and another in 1977.
- 3 AO (177 class) Fleet Oilers budgeted in 1976 and 1977.
- 1 AOR (1 class) Replenishment Oiler in FY 1972.
- 4 PHM (1 class) Guided Missile Patrol Hydrofoils budgeted in 1975.

Table E.10 summarized the ship classes and numbers of ships authorized over the study period.

TABLE E.10

Ships Authorized and Fiscal Year of Authorization

Type	1970	1971	1972	1973	1974	1975	1976	1977
SSN	3	4	5	6	5	3	2	3
TRIDENT	-	-	-	-	1	2	1	1
DD	3	6	7	-	7	7	-	-
FFG	-	-	-	1	-	3	6	8
CVN	1	-	-	-	1	-	-	-
CGN	1	1	1	-	-	1	-	-
LHA	2	2	-	-	-	-	-	-
AD	-	-	-	-	-	1	1	1
AS	-	-	1	1	-	-	-	1
AO	-	-	-	-	-	-	2	1
AOR	-	-	1	-	-	-	-	-
PHM	-	-	-	-	-	4	-	-

(2) Factors Considered in Making Selections

Many factors were considered in the review process before a recommendation was made as to the ships to be selected for tracking. The written record, particularly reports of Congressional hearings, discuss in some detail the problem of cost growth over original estimates, the rapidly rising cost of naval ships (aside from the growth problem), the quality of Navy estimates, the diminishing number of shipyards in which naval ships are being constructed, shipyard attitude toward Navy and vice verse, contract administration procedures and the like. These problems are amplified in the many documents reviewed. They assisted in focusing in on the criteria requiring review prior to recommending the specific ships that are studied. The criteria that were considered pertinent and on which discussion follows include:

- Size of the program -- This criterion is used to weight the larger of the ship programs with the view that it is best to direct effort to the areas consuming the greatest amount of resources.

- Size of cost growth -- Since the study was prompted by the amount of cost growth being experienced on SCN programs and the magnitude of claims submitted by shipbuilders on their contracts, the subject matter is an important factor in the selection process of ships to be chosen for in-depth tracking.

  As has been previously discussed, the size of the cost growth is considered in this study to be a function of the current estimated cost versus the "original estimate."

The original estimate is defined as "estimate made available to the Congress on which funding actions for advance procurement and/or authorization of a new ship or class of ships were based." On the basis of this definition, ships experienced significant cost growth.

- <u>Ship type</u> -- The type of ship selected for detailed study was an important consideration in that an insight might be provided as to the impact on the overall problem of cost growth of the problems inherent in estimating entirely different types of ships.

  From the point of view of ship type alone, the ships authorized for construction in Fiscal Years 1970-1977 provided a suitable mix from which to select three types for detailed review. Within each of the categories indicated in the study specifications, i.e., a nuclear ship, a non-nuclear combatant ship and an auxiliary ship, there were at least three types from which to make selections.

  The combatant ships covered a broad spectrum of size, configuration, manning, armament and mission. They ranged from aircraft carriers measuring almost 1100' and carrying over 5700 people for whom living and working accommodations must be provided, as well as complex systems for operating aircraft, to the 132' hydrofoil which carries 21 people and conducts offensive warfare while traveling at great speeds; and include subsurface as well as surface vessels. The auxiliary ships differ greatly from the combatant ships in hull form and content due to the supportive mission of these ships. All of these types require a great variety of talents to effectively and efficiently carry them through the various steps in the acquisition cycle.

- <u>Follow program</u> -- This criterion is premised on the possibility that study findings will have additional value if the ship on which findings are based is to be followed by a ship class having features similar to the case study ship. Similar hulls or similar weapon suites are examples.

- System integration complexity -- Because the difficulties encountered in integrating weapons systems into an effective total ship system have been a significant cost driver, it was determined that ships with the more complex weapons systems would be given preference in the selection process. The more complex the system, the greater the probability of integration problems, and the greater the estimating problem.

- Design -- Within the population of ships there were a number of different design processes being followed. They ranged from a simple repeat design to design to cost. Ships having more extensive or complex design requirements were given preference in the selection.

- Number of shipyards involved -- There was a potential advantage in having two or more shipyards involved in the construction of ships of the same class as the specific ships selected for review because cross-checking of estimates, proposals and performance reports would be possible. Exhibit E.2 contains information on ship construction assignments to the shipyards.

- Acquisition status -- The purpose of this criterion is to insure that ship programs in their infancy are not selected because, for these programs, the amount of useful data is limited. Comparisons of estimates to actuals are not possible on very new programs. Exhibit E.3 provides information on the status of each of the ship classes under consideration.

- Contract data -- The contracts under which the ships under consideration are procured usually include more that one ship. This makes data analyses more difficult, especially if a lead ship in included in the lot. Preference was given to single ship contracts and, then, to contracts including only follow ships.

- <u>Potential problems</u> -- It was considered that some of the ships in the population were more apt to experience problems which would effect cost and delivery after this study was completed than other ships. This would tend to reduce the usefulness of the study results. Accordingly, preference was given to ships that indicate a potential for fewer post delivery problems.

- <u>Claims</u> -- Preference was given to ships with the fewest claims as well as to ships constructed in shipyards which had lodged claims on only one ship type. The purpose was to reduce the impact of claims on the analysis of actual cost data. Exhibit E.4 contains information on claims outstanding.

(3) <u>Selection of Ship Classes to be Tracked</u>

The contractual guideline governing selection of ships for detailed study stipulated that a nuclear ship, a non-nuclear combatant ship and a naval auxiliary be included.

The ship selection process was an iterative one in which the criteria discussed previously were used by the study team to develop recommendations for the specific ship selections. The first step eliminated from further consideration ships that presented problems in analysis that would not contribute to the meaningfulness of the review.

The process used and a complete list of ship classes including the four ship classes eliminated during the first review is summarized below:

• NUCLEAR SHIPS —

-	CGN 38	Pass first review
-	CVN 68	" " "
-	SSN 688	" " "
-	TRIDENT	Eliminated in first review: the TRIDENT program is managed by NAVMAT, not a direct party to the contract. Also progress was not as far advanced as for the other ships.

• NON-NUCLEAR COMBATANT SHIPS

-	DD 963	Pass first review
-	FFG 7	" " "
-	LHA	Eliminated in first review: was first Navy ship of the type to be constructed in the new shipbuilding facility. Problems associated with its construction would likely be difficult to separate from problems incident to the shipyard's construction.
-	PHM	Eliminated in first review: those authorized for construction out of SCN funds were not under contract and, since it was a unique type of ship, it was being built in a facility other than a typical shipyard.

- NAVAL AUXILIARIES

  - AD 41 — Pass first review
  - AOR 7 — " " "
  - AS 39 — " " "
  - AO 177 — Eliminated in first review: these ships were placed under contract in August 1976 and progress was minimal.

Two additional ships were eliminated in the second review for the reasons shown below:

  - AS — This ship type was ruled out since a nuclear submarine was to be selected.

- NUCLEAR SHIP

  - CVN — Armament is less complex than the other nuclear types and, if the CVN had remained in the running, it might have ruled out the submarines, leaving 2 surface ships both of which were being constructed in the same shipyard. The CGN was considered as more a representative type for the surface ship selection.

Elimination of the CVN and AS left at least two acceptable candidates in each category. At this point, the criteria previously

described was applied to determine the ship classes from which the individual ships would be selected.

The application of each of the criteria proceeded as follows:

- <u>SSN 688 Class vs. CGN 38 Class</u>

- Program Size	The SSN with an estimated 39 ships in Class and $9,629 million cost greatly exceeded the CGN program which stood at 4 ships and an estimated $1,244 million cost.
- Cost Growth	Growth in unit cost left no clear cut choice.
- Ship Type	Submarine represented approximately half of the acquisition program and they require a special discipline in design and construction.
- Follow Program	The CSGN strike cruiser, designed to carry the AEGIS. Weapon System, was considered as a follow to the CGN.
- Systems Integration Complexity	The CGN weapons system was considered to be more complex.
- Design	No clear choice.
- Number of Shipyards	SSN construction was in 2 shipyards versus 1 for CGN.

- Acquisition — No clear choice. One ship hadbeen delivered in each program; follow ships were under construction.

- Contract Data — No clear choice; both programs have multiple ship awards.

- Potential Problems — Anticipate extended post delivery period with attendant problems in preparing CGN for performance of intended mission, vis. Complex weaponry. Therefore, the SSN was preferred.

- Claims — Claims are in hand from Electric Boat on SSN and from Newport News on SSN and CGN. Dealings with Electric Boat would be less confusing since only one ship class is involved. Therefore, the SSN was preferred.

It was determined that the SSN program would be included in the ships selected for tracking.

- <u>DD 963 Class vs. FFG 7 Class</u>

  - Program Size — The FFG program was planned for 74 ships at a cost of approximately \$13 billion; the DD program stands at 30 ships estimated at \$3 billion.

  - Cost Growth — The apparent growth in the FFG program was far in excess of that on the DD program.

-	Ship Type	No choice.
-	Follow Program	The DDG-47, a new class of destroyer designed to carry the AEGIS Weapon System, was considered as a follow to DD 963 class.
-	Systems Integration Complexity	The DD systems were considered to be more complex.
-	Design	The FFG 7 was a design-to-cost ship.
-	Number of Shipyards	FFG construction is in 3 yards versus 1 for the DD 963.
-	Acquisition Status	5 of the DD 963's had been delivered and follow ships were in various stages of construction; the first FFG was approximately 65% complete with delivery estimated for December 1977.
-	Contract Data	The FFG 7 was a single ship contract, followed by separate multi-ship contracts involving three shipyards. Bath reports in conformance with DOD 7000.2. The DD 963 program started with a lead and 2 follow ships on one contract.
-	Potential Problems	FFG appeared to have fewer problems. Therefore it was preferred.
-	Claims	None on either program; both were considered potential candidates for claims.

The choice here was difficult, but after reviewing each of the criteria, the study group recommended the FFG.

- AOR 7 vs. AD 41 Class

- Program Size	The AD program was planned to include 5 ships and cost $1,348 million versus 1 AOR at an estimated end cost of $86 million.
- Cost Growth	The estimated cost growth on the AD program greatly exceeded that on the AOR 7.
- Ship Type	No clear choice.
- Follow Program	No indication; however, there were more AO types for comparison than tenders.
- System Integration Complexity	The AOR had more weapons.
- Design	AD was a recent modification; the AOR was a repeat design.
- Number of Shipyards	AOR 7 was a single ship program; however, previous AORs were built at General Dynamics, Quincy to same design. ADs are in one yard.
- Acquisition Status	The AOR 7 was recently delivered; the ADs were just getting started in construction.

- Contract Data — The latest AOR was a single ship contract; the ADs were awarded under single ship contracts.

- Potential Problems — The AOR was complete and should be free of construction problems; the AD has yet to be constructed. Therefore, the AOR was preferred.

- Claims — No existing claim on the AOR 7; no claims submitted on the AD to date.

The selection decision was influenced by the status of the ships relative to the acquisition cycle. The AOR, which had been delivered and had a relatively complete record of events, provided an opportunity for detailed review through all phases of acquisition. Accordingly, the AOR was recommended for tracking.

(4) Three Ships Were Selected, Two Were Approved By The Navy For Tracking, The Third Rejected And A Substitute Directed

The ships of the SSN 688 program are being constructed in two shipyards, Newport News Shipbuilding and Dry Dock Company and General Dynamics Corporation, Electric Boat Division. The first consideration was the shipyard. In consideration of the claims situation that prevails between Newport News and Navy, on prior programs as well as the SSN, opinion was that one of the ships under contract

with Electric Boat could be tracked more thoroughly, with input provided by the shipyard as well as the Government. The selection process then concerned itself with which of the ships at Electric Boat to recommend. Since there was little choice but to track the lead ship in the non-nuclear combatant category and a single ship in the auxiliary category; study of a follow ship would round out the mix of lead yard/lead ship and follow yard/follow ship. Therefore, the SSN 696 was recommended for tracking. The construction schedule for SSN 696 was about one year behind SSN 690; the first ship of this class was under construction and nearing completion at Electric Boat and about 1-1/2 years behind the SSN 688. The SSN 696 was, during the selecting of ships, approximately 70 percent complete and projected for delivery in April 1978. The selection of the SSN 696 was not approved by the Navy. As an alternative, the SSN 678, U.S.S. ARCHERFISH, the twenty-fourth ship of the 637 class was selected by the Navy. It was the first of the long hull 637 class submarines to be built.

The FFG 7 was the logical choice for tracking in this category. It was the lead ship of the class and was currently under construction in the lead yard. There were two other yards involved in the program, as follow ship contractors. FFG 7 was estimated to be approximately 90 percent complete, with delivery estimated in December 1977.

The AOR 7 was the only ship of that type authorized in the period covered. It was constructed by National Steel and Shipbuilding Company and delivered on October 14, 1976. It was of the AOR 1 class. All prior ships of this class were constructed by General Dynamics, Quincy Division in the late 1960's.

3. EIGHT ITEMS OF GFM WERE SELECTED BY THE NAVY AS BEING PERTINENT TRACKING CANDIDATES

Government Furnished Material constitutes such a significant amount (in some cases 30 percent) of the total cost of Navy ships, including propulsion, weapons, radar, sonar, fire control systems, computers and related equipment. As such, the following items of GFM were researched as part of this report:

- AN/SPS-55 Surface Search Radar
  A conventional x-band radar capable of detecting medium and large line of sight targets and small targets at close range.

- PHALANX Close-In Weapons System
  A unitized, completely automatic gunnery weapon designed to recognize, track, fire on and destroy a missile within its operating area.

- 5" Lightweight Gun, MK 45
  A fully automatic, lightweight, shielded single-barrel weapon firing 5" projectiles at about 20 rounds per minute.

- MK 86 Gun Fire Control System
  A gun fire control system for surface to surface and surface to air (aircraft and missile) weapons.

- <u>AN/UYK 7 Digital Computer</u>
  A modular, general purpose digital computer for shipboard application for weaponry and administrative computing.

- <u>AN/SPS 40 Air Search Radar</u>
  A lightweight air search radar for detection of high and low flying targets.

- <u>AN/SQS 53 Sonar</u>
  A surface ship sonar providing detection, classification and localization of underwater targets as part of ASW mission.

- <u>LM 2500 Gas Turbine Engine</u>
  An advanced propulsion unit developed from aircraft technology. It is a simple cycle two shaft high performance engine generating 27,500 horsepower with necessary support subsystems.

Correlation of the specified systems to selected ships which follows in Talbe E.11 is furnished for information.

TABLE E.11

<u>Correlation of Ships to GFM</u>

SYSTEM	INSTALLED ON		
	SSN 678	FFG 7	AOR 7
AN/SPS-55 surface search radar		Yes	
CIWS - close in weapon system		Space	Space
5"/54 lightweight gun			
MK 86 gun fire control			
AN/UYK-7 digital computer		Yes	
AN/SPS-40 air search radar			
AN/SQS-53 sonar			
LM2500 gas turbine		Yes	

4. A NUMBER OF POTENTIAL COST DRIVERS WERE IDENTIFIED EARLY AND EACH SHIP OR WEAPONS CASE WAS EVALUATED AGAINST THESE ELEMENTS

Cost overruns are the product of many factors operating together. Examples of these factors can be identified in Navy records, commissioned studies, Congressional testimony, etc. It is these factors that this study addresses and, in this section, a case by case analysis is made of them. In order to facilitate consideration of them, classifications were developed to group related cost factors which, although not totally precise, tend to add clarity to an otherwise lengthy list of factors. The groupings follow:

Programming/Budgeting

- Constraints on estimates -- These constraints either may be arbitrary or result from policies such as design-to-cost.
- Unanticipated escalation -- Escalation rates may be higher than anticipated.
- Reduced program -- Fewer ships than expected may be authorized and awarded, affecting learning curve cost predictions.
- Program uncertainties -- Uncertainties created by appropriations decisions cause shipbuilders/component suppliers to sub-optimize capital investment and work with less productive labor/capital mix.
- Additional stock units -- More units may be required for initial stock or rotation than originally projected.

Technical Definition

- Insufficiant information -- Characteristics and configuration data may be inadequate for an estimate of reasonable quality.

- System upgraded -- More expensive weapons or other systems may be substituted for systems originally incorporated in the ship.

- Additional systems -- Extra systems may be incorporated in the ship after original estimates are made.

- Additional specifications -- Additional or more stringent application of specifications such as quality assurance, maintainability, shock resistance, etc. after original estimates are prepared.

- Incorrect plans -- Plans and specifications may be incorrect or not in agreement, referenced documents difficult or impossible to obtain.

- Late changes -- Changes made to plans and specifications after shipbuilder's plans are firm or work has progressed to the point where the change may have a disruptive effect.

Estimating

- Poor estimates -- Estimates for ships and components may be inaccurate because of faulty procedures, data banks, etc.

- Inadequate time to estimate -- Lack of time to prepare proper estimates due to short deadlines or insufficient resources.

- Changed market conditions -- Market conditions different than predicted when estimate was made.

- Less efficient shipyard -- Shipyard receiving the award may be less efficient that shipyard considered when estimate was made.

- Low productivity -- Inability to forecast productivity levels and adjust estimates accordingly.

- Fewer shipyards -- Fewer shipyards than expected bid or propose on work, resulting in higher profit demands.

- Retention of shipbuilding base -- Award of contract to less capable shipyard in order to provide work volume and keep shipyard operating.

Personnel

- Management instability -- Changes in Navy management personnel that may affect the stability and quality of project management.

Scheduling

- Delay of scheduled events -- Error may be introduced into estimates because events such as funding and award are delayed.

- Poor scheduling -- Schedules may be too optimistic, resulting in understating escalation and general disruption in the shipbuilder's plant.

- Late GFE/GFI -- Government Furnished Material delivered late or in error.

Contracting

- Poor form of contract -- Selection of method of contracting such as sole source which may result in costs higher than estimated.

Construction

- Technical difficulties -- Unanticipated technical difficulties may be experienced by shipyard or component manufacturer.
- Shipbuilder's backlog -- Backlog in the shipbuilder's plant may affect the shipbuilder's bid or proposal or may cause slippages due to other work.
- Low productivity -- Productivity in shipyard or component manufacturer may be lower than projected.
- Work stoppages -- Work Stoppages or slowdowns in shipyard or component manufacturer.
- Mismanagement -- Mismanagement in shipyard or component manufacturer's operation.
- Inadequate facilities -- Proper facilities may not be available requiring uneconomical performance on some work or may require provision for additional facilities.
- Labor shortage -- Unable to hire the numbers of employees or skill levels needed to maintain shipyard schedules or high labor turnover.

Government Programs

- Management layering -- Delays may occur in the decision process due to the time required to acquaint layers of management with pertinent facts.
- Excessive management systems -- Requirement by government for data and management systems may be in excess of projections.
- Excessive inspection -- Government inspectors may be more rigid in applying inspection standards than anticipated.

- Social programs -- Requirements of OSHA, EEO and other Government social programs may be more stringent than expected.

- Delay in Government actions -- Excessive time may be taken by the Government in technical approvals, processing proposed changes and plan revisions.

The development of consistently accurate cost estimates requires that these kinds of factors be considered and allowed for where necessary. This is not an easy task when the complexity of the ship, the length of the building period and the complications of the management process are considered.

III. CASE STUDY OF THE AOR 7

The AOR 7, the seventh ship of the class, was authorized in the FY 1972 Shipbuilding Program. The original end cost estimate forwarded to Congress in January 1970 was $56.5 million. Under a contract awarded to the National Steel and Shipbuilding Company in December 1972, the ship was delivered to the Navy on 14 October 1976 at an estimated end cost at delivery of $86.3 million, an apparent overrun of approximately 53 percent.

This chapter will follow the AOR 7 from the original statement of the requirement through the preparation and submission of budget estimates, the pre-award, the award and construction phases to ship delivery. In so doing, this chapter has -- through interviews, records review and analysis -- set forth the history of the cost growth, apparent and actual.

1. THE REQUIREMENT FOR THE AOR EVOLVED FROM THE NEED TO UPGRADE UNDERWAY FLEET REPLENISHMENT

The AOR 7 is a multipurpose replenishment ship designed to provide rapid replenishment of petroleum products and selected ammunition items and to provide limited amounts of chilled and frozen provisions, repair parts, other consumable stores, and fleet freight to operating forces at sea.

When it was first included in a budget, the AOR was a new type of ship that was authorized in FY 1965. The ship is designated a Replenishment Oiler and is one of five ship types classified as Underway Replenishment Ships in the Auxiliary Ship group. Subsequent AOR class acquisitions are summarized below:

- Contracts for AORs 1 through 6 were awarded to General Dynamics-Quincy. The U.S.S. WICHITA AOR 1, the lead ship of the class, was delivered in May 1968, 13 months behind schedule at a cost of $41.0 million.
- The last of the class built by General Dynamics-Quincy, the U.S.S. KALAMAZOO AOR 6, was delivered in July 1973, 30 months behind schedule at a cost of $43.7 million.
- The AOR 7 was authorized in June 1971 with the FY 1972 shipbuilding program to replace an older ship of questionable reliability which was then approaching 36 years of service.

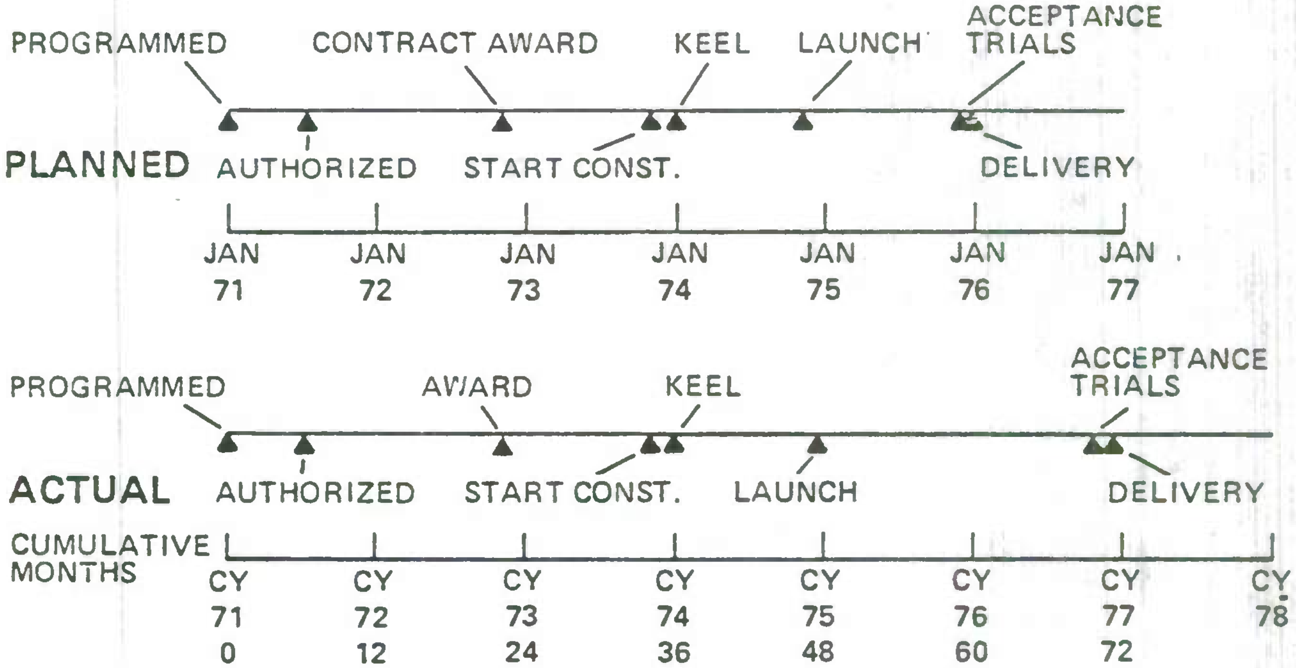
An overview of the AOR 7 development is shown in Figure E.3.

2. THE REPLENISHMENT OILER AOR 7 WAS INCLUDED IN THE FY 1972 SHIPBUILDING PROGRAM

The estimated end cost of AOR 7 as originally forwarded to Congress in January 1971 was $56.5 million. This estimate, including escalation, growth allowances and other contingencies was derived in conjunction with a series of program planning and budgeting reviews. Tables E.12 and E.13 provide an overview of changes between the original estimate and the final

FIGURE E.3

AOR 7 ACQUISITION PROGRAM



end cost which will be discussed in successive sections of this chapter.

TABLE E.12

COST HISTORY OF AOR 7
(Dollars in Millions)

	End Cost Estimate	Estimated Basic Construction Cost (Unescalated)	Classification	Remarks
2 April 1970	70.9	46.7	F	POM Preparation
12 June 1970	68.5	44.7	D	POM Submit
28 September 1970	65.5	44.7	D	SECNAV to OSD Budget Submit
19 November 1970	56.5	41.7	F	PBD Reclama
17 December 1970	58.5	43.4	F	NAVSHIPS to OP-NAV Budget Reclama
18 December 1970	56.5	41.7	F	Approval and Budget Submit
14 December 1972	68.0	48.1	F	Reprogramming Action
14 October 1976	86.3	61.4	-	End Cost

The construction contract was awarded to National Steel and Shipbuilding Company on 15 December 1972. The contract award was a fixed price incentive type amounting to $51.5 million.

The original budgeted end cost was increased by $10 million in a reprogramming action immediately prior to contract award. By the time the

ship was completed the NASSCO contract price had increased by approximately $20 million over the award price. This does not include costs for government furnished equipment, growth allowances and other government-responsible services and support which totals approximately $15 million.

TABLE E.13

AOR 7 INCREASE -- AWARD TO COMPLETION

Date	Event	Total Contract Price	Gov't. Responsible Costs	End Cost
15 Dec. 1972	Contract Award	$51.5 M	$16.5 M	$68.0 M
12 Nov. 1976	Post Delivery	$71.1 M	$15.2 M	$86.3 M

Table E.14 which follows identifies the changes in budgeted amounts between Congressional submission and ship delivery.

3. THE ESTIMATING AND PRE-AWARD PERIOD OF THE AOR 7 REFERS TO ACTIVITIES INVOLVED IN PLANNING, PROGRAMMING AND BUDGETING FOR THE FISCAL YEAR 1972 BUDGET

The period is typically characterized by continual testing of options to best utilize resources provided by OSD guidance for the POM and Budget submissions. Many pressures -- cost per ship, number of ships, characteristics lists, current or out-year programming -- all are mixed and matched to achieve the best program possible within the resources available. On

TABLE E.14

REALLOCATION OF AOR 7 BUDGETED FUNDS
(Dollars in Millions)

	Base	Changes Plus	Changes Minus	
Approved Congressional Estimated End Cost (December 1970)				56.5
Construction Plans	1.8	-	1.3	
Basic Construction	41.7	12.0	-	
Change Orders	2.1	0.6	-	
Electronics	0.9	0.1	-	
H/M/E	1.6	0.2	-	
Maintenance and Services	0.3	-	0.3	
Ordnance	4.5	-	1.4	
Escalation Growth	1.5	2.2	-	
Electronics Growth	0.1	0.1	-	
Change Order Growth	0.6	-	0.1	
Ordnance Growth	0.4	-	-.4	
Future Characteristics Changes	1.0	-	-	
Estimated End Cost (December 1972)				68.0
Construction Plans	3.9	3.0	-	
Basic Construction	48.1	16.6	-	
Change Orders	3.4	-	0.4	
Electronics	1.0	-	0.1	
H/M/E	2.7	0.5	-	
Maintenance and Services	0.6	1.1	-	
Ordnance	3.6	1.9	-	
Escalation Growth	3.7	-	3.3	
Electronics Growth	0.1	-	-	
Change Order Growth	0.6	-	0.6	
Ordnance Growth	0.3	0.1	-	
Future Characteristics Changes	-	-	0.5	
Estimated End Cost (October 1976)				86.3

occasion, this type of options "game" is played to excess. The objective, finally, is to put forward a program which meets Navy requirements and has a high probability of Congressional approval. The compromises attendant to such a process necessarily impact over the life of the ship procurement. This was evident in the AOR 7 acquisition.

Estimating problems during the early period were caused chiefly by changing and sometimes confusing characteristics lists and, further, by constant pressures to settle on a lower end cost figure. A chronology of events during this period is found in Table E.15.

(1) Early In The POM 72 Cycle, CNO Requested A Price Out Of Five Ships For The Years Of FY 1973 And FY 1974

The POM cycle begins in July or August -- some 27 months prior to the budget submittal -- with staff work on potential ship acquisition profiles to be included in the five year plan. During these staffing activities in OPNAV and the Systems Commands, CNO provides guidance as to number of ships per year and desired characteristics. In the case of the AOR 7, this guidance was issued in September 1969. It requested five ships (two in FY 1973 and three in FY 1974) of a modified, repeat design based on AOR 5 and 6 specifications. All changes in the AOR class developed over the three previous acquisition flights, such as class items, field and

TABLE E.15

CHRONOLOGY OF EVENTS LEADING UP TO ISSUANCE OF REQUEST FOR CONSTRUCTION CONTRACT BIDS

Date	
15 Sept. 1969	CNO directed that FY 72 AOR be a modified repeat design of the FY 1966 AORs (Hull Numbers 3 and 4) and requested price-out.
19 Mar. 1970	NAVSEC completed FY 1972-76 SCN Program Modified Repeat Design Feasibility Study.
2 Apr. 1970	NAVSHIPS submitted class "F" estimate for FY 1973 AOR costed at $70.9 million.
12 June 1970	NAVSHIPS resubmitted FY 1973 AOR estimate as $68.5 million, class "D."
28 Sept. 1970	CNO directed AOR be included in FY 1972 program. Repricing produced new estimate of $65.5 million, class "F."
16 Nov. 1970	OSD (PBD 81) challenged FY 1972 AOR estimate of $65.5 million as exorbitant. Section 4 discusses in detail.
19 Nov. 1970	SHAPM (PMS 383) resubmits revised class "F" estimate of $56.5 million for FY 1972 AOR.
30 Nov. 1970	SHIPS 06(01G) disagrees with reduced estimate and states estimate not budget (class "C") quality due to arbitrary changes and lack of change documentation.
17 Dec. 1970	COMNAVSEA advises OPNAV that reclama budget estimate of $56.5 million cannot be classified better than class "F" due to lack of hard cost data on pollution abatement changes.
18 Dec. 1970	PBD 81R approves retention of FY 1972 AOR at estimated end cost of $56.5 million.

TABLE E.15
(continued)

Date	
29 Jan. 1971	NAVSEC given advance notification of intent to issue SPD for FY 1972 AOR contract design.
11 Feb. 1971	NAVSHIPS and CNO held conference to clarify CNO-directed characteristics changes.
19 Feb. 1971	Additional deliberation relative to FY 1972 AOR changes to established electronics characteristics. NAVSHIPS directed to prepare cost estimate incorporating electronics change, but adhering to end cost estimate ($56.5 million).
23 Feb. 1971	SHAPM and NAVSEC agreed on procedures for the conduct of the FY 1972 AOR contract design.
14 Apr. 1971	NAVSEC tasked per SPD to prepare Contract Design Package for FY 1972 AOR.
23 July 1971	SAIC approved certain changes to the FY 1972 AOR characteristics which included NATO SEASPARROW and two 20 mm guns vice four 3" 50 with two MK 87 GFCS.
28 July 1971	CNO approved FY 1972 AOR ships characteristics.
Aug. 1971	Ship Cost Adjustment Report (SCA) shows FY 1972 AOR budgeted for $56.5 million.
6 Aug. 1971	NAVSEC commenced redesign for late characteristics changes.

headquarters-initiated changes; and operational evaluation items were to be included in the design baseline. Further, new characteristics were specified in ordnance, habitability, pollution abatement, helicopter handling, refrigeration compartments and electronics.

In reviewing estimating activities during this period, a question arises as to whether AOR 7 was a new class ship or actually a routine modification of a current or existing class of ships. The answer to this question impacts the estimate classification. If changes accumulated on prior ships had been routinely incorporated in the class design, one might expect a class "B" estimate; however, these changes were thought by NAVSEA estimators to be substantial and precluded extensive utilization of cost experience from past ships resulting in the class "F" estimate available at time of budgeting.

Toward the end of the POM cycle the estimates for the AOR 7 and four other AORs were classified as "F" and were issued in the Tentative POM Documents as follows:

.	FY 1973	AOR 7	$70.9 million
.	FY 1973	AOR "8"	60.1 million
.	FY 1974	AOR "9"	60.1 million
.	FY 1974	AOR "10"	59.6 million
.	FY 1974	AOR "11"	59.1 million

or

- Five ships over two years for $310 million in FY 1972 dollars.

The $70.9 million estimate for AOR 7 implies, by class "F" designation, an initial reaction by NAVSEA that ship changes and updates as approved were sufficient to consider it almost a new class which would cost substantially more than any of the first six AORs -- the last of which was completed at $43.7 million.

(2) <u>At The Start Of The FY 1972 Budget Cycle, The AOR Costs Were Refined To A Class "D" Estimate</u>

The preparation of the NAVCOMPT Budget starts in June of each year when the first of the POM years is re-analyzed and becomes the basis of the Navy budget. The intervening time presumably allowed more study of the characteristics changes resulting in an assumption that the ship was well-defined. The class "D" estimate was $68.5 million for the FY 1973 planned award.

During the budget cycle, the NAVCOMPT, CNO and SECNAV Hearings produced a revised plan and, in the last days before the OSD budget submission, a repricing of the AOR 7 for FY 1972 was requested by CNO.

This price-out came during a time of great pressure in the budget process. The Navy hearings mentioned all take place within the same month and, to further complicate matters, OSD budget guidance is published during the same period. The total time between the last hearing (SECNAV review) and the OSD submit is typically only a few days. Consequently, the revised AOR 7 estimate for the FY 1972 budget year was completed in about one day. The resulting revised end cost estimate was $65.5 million (Class F), which was forwarded for OSD/OMB review on 28 September 1970. As seen in tabulation below, the majority of estimate reduction was achieved by reducing the escalation allowance. Table E.16 details the estimate change.

TABLE E.16

BREAKDOWN OF AOR 7 ORIGINAL VS. REVISED BUDGET ESTIMATES
(Dollars in Millions)

Cost Category	Original POM Submit Class "D" (5/22/70)	Revised POM Submit Class "F" (9/28/70)
Plans	1.9	1.9
Basic Construction	44.7	44.7
Change Orders	3.6	3.6
Electronics	1.2	1.3
H/M/E	1.8	1.8
Ordnance	8.0	8.0
Escalation	4.6	1.5
Future Char. Changes	1.7	1.7
Other	1.0	1.0
Total	68.5	65.5

(3) <u>CNO Questioned The High Cost Of The AORs And Directed A Cost Study</u>

The case of the AOR 7 is characterized by a seemingly greater than ordinary pressure to reduce the projected cost (or the estimate) to something approaching the cost of the previous AORs. Throughout the POM and Budget cycles, this pressure was evidently without regard to definitive data concerning the increased costs for characteristics changes.

In October of 1970, CNO took a different approach to price reduction. A Cost and Feasibility Study was directed which specified an inventory objective of five ships at a target price of $175 million. This was similar to a Design-to-Cost project (DTC = $35 million). The study was scheduled for completion by the end of October, however, which precluded it from being a full-fledged feasibility study. The study was conducted during the OSD/OMB review and overlapped the start of the OSD Program Budget Review (PBD).

(4) <u>The PBD Process Eliminated AOR 7 From The FY 1972 Program On The Grounds That Its 62 Percent Increase In Cost Over AOR 6 Made It A Poor Investment</u>

The PBD process is a dialogue between Navy claimants and OSD management regarding options for balancing current budget

resources. PBD's are staffed in advance of the formal process and are issued early in the schedule -- first as tentative decisions, later as final. This process eliminated the FY 1972 AOR as a poor investment due to the difference between the $43.7 million end cost of AOR 6 and the $70.9 million CNO price-out for the FY 1972 ship.

PBD #81, which dropped the FY 1972 AOR from consideration, was responded to by OPNAV on November 19, 1970, with a reduced end cost estimate of $56.5 million and a request for reinclusion in the FY 1972 budget. Further, it was asserted that the estimate was a class "C" estimate. This view by OPNAV was addressed in a November 30, 1970 internal memorandum by SHIPS 06 (the NAVSEA estimators) in which they stated objection not only to the amount, but also the "C" classification. The resultant $9 million reduction was considered by SHIPS 06 (01G) to be arbitrary and undocumented with regard to characteristics changes. It was further recommended by them that approximately $4.5 million be reinstated to cover Integrated Logistics Support, NAVSEC customer funding, and change order growth. Table E.17 summarizes the estimate reductions.

TABLE E.17

BREAKDOWN OF AOR 7 RECLAMA ESTIMATE

	Sept. 1970 FY 1972 POM Class "F"	Nov. 1970 PBD #81 Reclama Class "F"	Difference
Plans	$ 1.9 M	$ 1.8 M	$0.1 M
Basic Construction	44.7	41.7	3.0
Changes	3.6	2.7	0.9
Electronics	1.3	1.0	0.3
Non-electronics	1.8	1.6	0.2
Ordnance	8.0	4.9	3.1
Other Cost	1.0	0.3	0.7
Future Characteristics Changes	1.7	1.0	0.7
Escalation	1.5	1.5	-
Total	$65.5 M	$56.5 M	$9.0 M

(5) The Final PBD Reinstated The AOR 7 In FY 1972 At $56.5 Million

One of the contingency issues discussed during the PBD process was the inclusion of long-lead funding for an aircraft carrier. Subsequently, this long-lead requirement was dropped. The AOR 7 estimate, apparently falling within the amount of funds then available, was reinstated at the reclama end cost estimate of $56.5 million. This figure prevailed and was included in the President's Budget for Fiscal Year 1972. It thus becomes the standard against which bid figures and actual costs are measured.

Looking ahead to what the AOR 7 would ultimately cost, it must be concluded that the "players" in the Program Planning and Budgeting process were in a large measure responsible for changing an estimate which was within 18 percent ($70.9M) of the end cost to one which was within 35 percent ($56.5M) of final cost ($86.3M).

Note: Figures E.4a and b show the administrative process and the key actions taken in those processes.

4. <u>A REVIEW OF THE EVENTS LEADING UP TO THE AOR 7 CONTRACT AWARD IN DECEMBER 1972 AND THE DEVELOPMENT OF THE AOR 7 CONTRACT DESIGN INDICATES THAT SHIP DEFINITION WENT THROUGH CONSIDERABLE CHANGE BOTH DURING AND AFTER THE SUBMISSION OF THE BUDGET ESTIMATE</u>

With AOR 7 as the seventh ship of a class, design update would be expected to be minor and thus provide a solid basis for end cost estimates. The budget end cost estimate as submitted to the Congress in January 1971 was Class "F." The reasons for this are found in the various manipulations of characteristics and lack of design documentation. A summary of the AOR 7 design update follows:

- Characteristics Update Commenced With FY 1966 AOR As Baseline.
  - In September 1969, CNO directed that the FY 1972 AOR be a modified repeat design of the FY 1966 (AOR 3-4) SCB Project 707:66 dated September 1964

FIGURE E.4A

ADMINISTRATIVE PROCESS

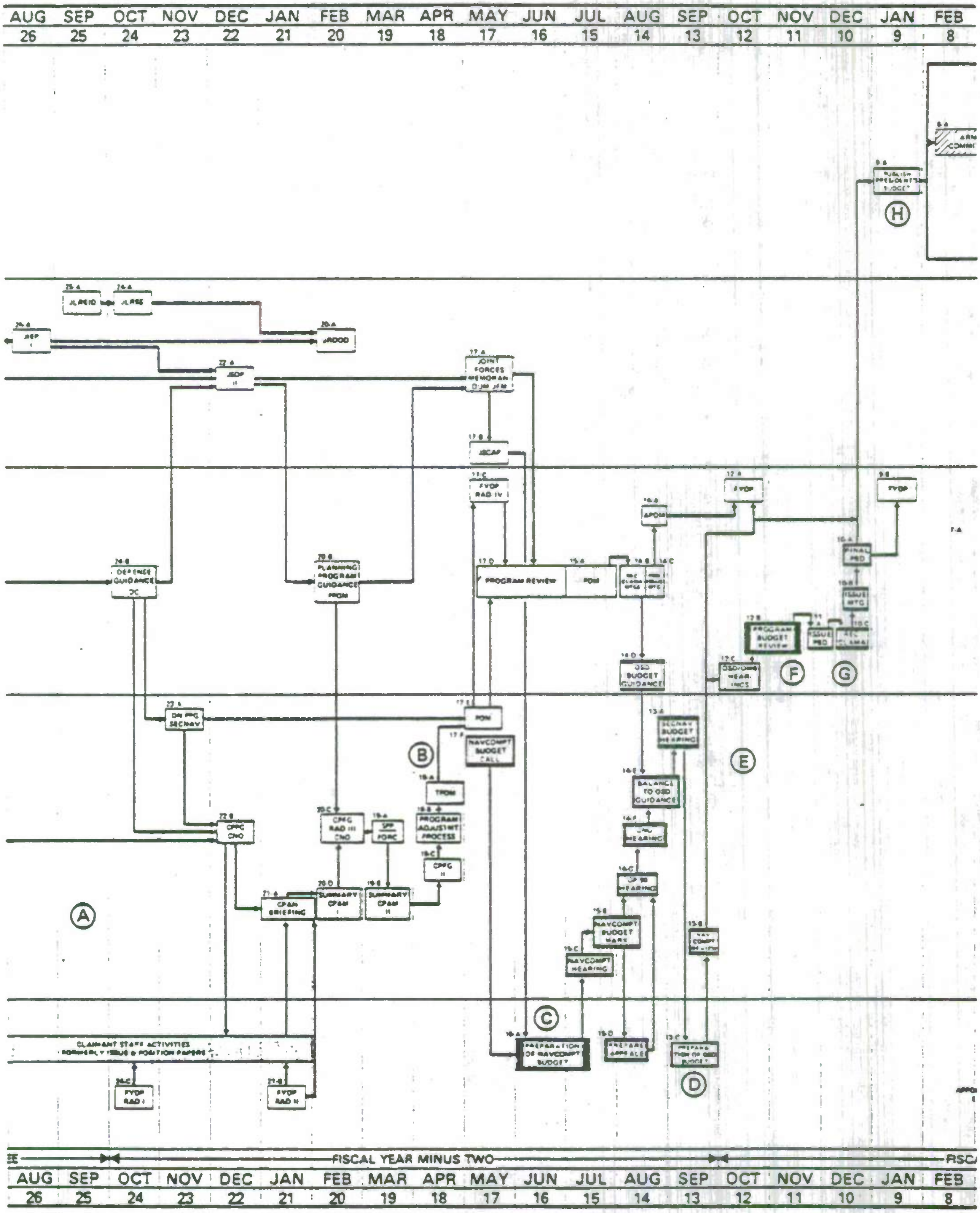


FIGURE E.4B

KEY ACTIONS

Key	Event	Estimate (Millions)	Cumulative Difference (Millions)
A	September 1969 -- CNO directed that FY 72 AOR be modified repeat design of FY 1966 AORs (Hull No. 3 and 4) -- CNO requests price-out of modified repeat design		
B	2 April 1970 -- NAVSHIPS "F" estimate of \$70.9 million for AOR 7 and about \$10 million less for follow ships	\$70.9	
C	12 June 1970 -- NAVSHIPS upgrade to "D" estimate of \$68.5 million	68.5	(\$2.4)
D	Repricing in FY 72 program per CNO request is \$65 million	65.5	(5.4)
E	C&F study commissioned by CNO -- cost objective to be \$35 million		
F	PBD #81 eliminates ship; response to reinstate shows estimate of \$56.5 million	56.5	(14.4)
G and H	Estimate prevails	56.5	(14.4)

modified by designated changes in the areas of habitability, increased accommodations, cargo capacities, helicopter facilities, pollution abatement, communications and ordnance.

- NAVSHIPS (now NAVSEA) in June 1971 advised the CNO that while the FY 1966 characteristics applied to the AOR 3 and 4, NAVSHIPS was using AOR 5 and 6 (FY 1967) as a design baseline and noted that no AOR 5 and 6 characteristics has been promulgated.

- The decision to use the AOR 5 and 6 as a design baseline was reached after a series of conferences between OPNAV and NAVSHIPS personnel (February - April 1971) which were conducted to clarify characteristic changes for the modified repeat design AOR.

- The establishment of the AOR 5 and 6 design baseline recognized that the AOR class had been going through routine evolutionary changes which had been documented only in various memoranda and single sheet characteristic changes.

. FY 1972 AOR Characteristics Approved By Ship Acquisition And Improvement Council (SAIC) OPNAV On 28 July 1971 and ultimately promulgated In February 1972.

. NAVSEC tasked on 14 April 1971 to prepare contract design package for FY 1972 AOR.

. Preliminary/advance notification to NAVSEC was forwarded in January 1971.

. AOR 5 and 6 specifications and drawings were used as a baseline modified to incorporate

  - CNO promulgated characteristics changes with weight differences as summarized in Tables E.18 a and b.

  - AOR 5 and 6 Headquarters Modification Requests (HMRs)

- AOR 5 and 6 Field Modification Requests (FMRs)
- AOR 1 Class Items
- Miscellaneous SHAPM initiated changes based on AOR 1 operational evaluation and operational experience.

Further, as seen from Table E.18a below, these major characteristic changes were broad in scope and impacted nearly all areas of the ship. Weight differences associated with these changes are tabulated in Table E.18b which follows.

TABLE E.18a

CHARACTERISTICS CHANGES

Characteristics: Modified repeat design of AOR 5 and 6;
Approved by SAIC 28 July 1971;
Issued by OPNAV 24 February 1972

Major Characteristic Changes:

- Added Helicopter Hangar
- NATO SEASPARROW Missile System Vice 3"/50 RFTM
- Added Sewage Holding
- Ship to burn Navy Distillate and Navy Standard Fuel Oil
- Updated Communications
- Increased Accommodations
- Deleted AVGAS
- Increased Cargo Ammo and Reefer Stowage
- Improved Habitability
- Incorporated Oil Pollution Abatement Measures
- Software
    - Integrated Logistics Support (ILS)
    - Configuration Control
    - Data Requirements

TABLE E.18b

WEIGHT DIFFERENCES AOR 7 AND AOR 5

Group	Weight Tons	Change From AOR 5	Reasons
Hull Structure	8,243	+ 163	Helo Hangars, Machinery Flats, AVGAS Delete
Propulsion	1,098	+ 7	Delete Spare Boiler Tubes
Electric Plant	327	+ 8	MG Sets, Lighting Fixtures, Shore Power Cable
Communication & Control	129	- 5	Missile System, Delete MK 56 Radio Equipment
Auxiliary System	1,717	+ 44	Reefer Space, A.C. Plant, Sewage
Outfit & Furnishings	1,241	+ 107	Habitability, Sewage Tanks, Helo
Armament	179	- 14	New Weapon Suite
	12,933	+ 381	

Characteristics changes introduced during the design process, such as the incorporation of NATO SEASPARROW, delayed scheduled completion of the contract design as shown in the following table.

TABLE E.19

CONTRACT DESIGN SCHEDULE

	Original	Revised	Actual
Start contract design	1 April 71	1 April 71	1 April 71
Preliminary Specs to SHAPM	1 July 71	2 Aug 71	2 Aug 71
SHAPM completes Spec review	15 July 71	8 Sept 71	8 Sept 71
Final Spec approval (signature)	7 Sept 71	3 Dec 71	16 Dec 71

AOR 7 contract design was approved on 16 December 1971. Characteristic changes reflected in the completed design impacted all areas of the ship.

- Hull/Cargo/Unrep
  - Increased cargo, ordnance and reefer stowage
  - Updated to UH 46 helo plus two hangars
  - Deleted AVGAS and NSFO cargo, added ND, retained JP-5
  - Heavy (FAST) transfer heads replaced by light (AOE) heads

- Pollution Abatement
  - CHT-12 hour holding tanks with pumping facilities
  - Contaminated Oil Settling Tanks
  - New Cargo Fuel Level Indicators
  - Delete riveted seams at bilge
  - Add strake of HY-80 Plate

- Weapons
  - Changed armament to NATO SEASPARROW Surface Missile System
  - Added 20 mm guns
  - Retain space/weight for future installation

- Electrical/Electronics

  - Air Search Radar (SEASPARROW)
  - Consolidated communications under one room concept
  - Added two MK 19 GYRO Compasses, deleted MK 23
  - Added short range high resolution radar
  - Flag electronics allow space/weight
  - Added TACSATCOM (Space and Weight)
  - Deleted HF Secure Voice System

- Machinery

  - Foam to AFFF (light water) Fire Fighting
  - Substituted 20 SCFH H.P. air compressors for four SCFH units
  - Substituted new oil-free, dry-ship service air compressors
  - Rerouted uptakes to clear new Helo facilities

- Habitability

  - Sheathing for bulkheads and overhead in living, messing, recreation lounge and sanitary spaces
  - Rugs for living, recreation and messing spaces
  - Coordinated color scheme
  - Modernized galleys
  - CPO total living concept
  - Crew civilian clothes, new uniform stowage
  - New mess tables, stack chairs
  - Walk-in type ship store
  - Update and modernized laundry
  - New ships gym
  - First class P.O. messroom
  - Update A.C. plant for new STDS

The AOR 7, which was to be a modified repeat design, after an AOR construction hiatus of more than five years, incorporated numerous design modifications and characteristics changes which in retrospect may have warranted designation as a new class of AOR, and in the final analysis

proved to be a major factor in the greater than 62 percent cost increase over the AOR 5 and 6, which was the principal rationale advanced by OSD with their rejection of the original class "D" POM submission.

5. REQUEST FOR PROPOSAL # N00024-722-0574 WAS ISSUED TO ELEVEN PROSPECTIVE OFFERORS ON FEBRUARY 11, 1972

Although the bid closing date was extended one month, only three bids were received. These were based upon a five day review of prior ship plans at General Dynamics-Quincy. Best and final bids as requested were received on 5 October 1972. Following a $10 million reprogramming action, the construction contract for AOR 7 was awarded to National Steel and Shipbuilding Company on 15 December 1972. Events between the issuance of RFP and contract award are summarized in Table E.20.

(1) The Request For Proposal Marked The Beginning Of The Contractual Phase Of The AOR 7 In February 1972

The eleven prospective offerors were all competent shipbuilders but only three submitted bids. A review of events leading to contract award follows.

(2) Bidders Were Allowed Five Days To Review Some 1,500 Plans From The AOR 6 In Order To Prepare Their Bid On The AOR 7

Potential bidders were invited to visit General Dynamics-Quincy during the period 13-17 March 1972, for the purpose of

TABLE E.20

CHRONOLOGY OF EVENTS LEADING TO CONTRACT AWARD

6 Dec. 1971	Commenced preparation of the Request for Proposal (RFP)
16 Dec. 1971	Signature approval AOR 7 contract design package.
25 Jan. 1972	Schedule A, List of Government Furnished Equipment approved.
17 Feb. 1972	RFP issued.
13-17 Mar. 1972	Bidders review AOR drawings and other data.
6 April 1972	Bidders Conference.
13 June 1972	Bid closing date.
5 Oct. 1972	Best and final offers received.
14 Dec. 1972	SCN 1972 Serial # 73.5 reprogrammed $10.0 million and increased AOR 7 end cost estimate to $66.5 million.
15 Dec. 1972	Contract award to NASSCO.

reviewing approximately 1,500 plans and drawings from the AOR 5 and 6. The contract requirements for the AOR 7 directed that the detailed working drawings prepared by General Dynamics-Quincy for the AOR 5 and 6 were to be utilized to the maximum extent possible in the AOR 7. This requirement also provided that the successful bidder would modify the subject plans and drawings for compatibility with the involved yard's construction methods. The

five days provided for plan review was later confirmed by the Navy claim analysis group to be wholly inadequate for a detailed analysis and review of the working drawings. However, there is no record of any bidder requesting additional time to review the plans. Thus, the bids were developed on contract drawings, contract guidance drawings and specifications supplied as part of the RFP with only limited review of the working drawings.

(3) The Bidders Conference On The AOR 7 Occurred On Schedule In Preparation For The Bid Closing Date

The bidders conference took place on April 6, 1972 as scheduled. This session is a regular occurrance during the solicitation period of most ship procurements. The prospective contractors' technical questions concerning the scope of proposed work are answered during this session.

(4) On April 12, 1972, General Dynamics-Quincy Warned The Navy That The AOR 7 Was Under-Budgeted By Almost $25 Million

General Dynamics had informed the Navy, prior to the submission of bids, that hardware and software changes specified in the AOR 7 contract/design package would involve a large cost increase over the AOR 6. The cost information submitted by General Dynamics

showed a $55 million cost baseline for the AOR 6 design with potential increases of $8-11.5 million for hardware and $2-6 million for software for the new AOR 7 baseline. General Dynamics' maximum estimate was in excess of $70 million. NAVSEA agreed that $2.0 million more was needed, but disagreed with General Dynamics' pessimistic outlook regarding the lack of budgeted funds.

(5) The NAVSHIPS Independent Estimate Of Contract Price Just Prior To Bid Closing Was $55.5 Million (Including $5.06 Million Profit)

The Navy's independent estimate of the contract price for the AOR 7 was calculated just prior to the bid closing date. This estimate, used to judge the reasonableness and accuracy of contractor's bids, was $55.5 million or $12 million above the original amount ($43.5 million) budgeted for basic construction and plans.

In the case of the AOR 7, the use of an independent government estimate was basically a formality since the bids were competitive and the lowest bidder must usually be chosen, unless there is a valid reason for doing otherwise. But if comparison of offers proves insufficient competition exists, a more detailed analysis utilizing past prices, quantities, production and delivery rates should be performed if normal procedures are followed. In addition, negotiation

with the offerors is sometimes necessary to ensure acceptable pricing.

(6) <u>The Bid Closing Date Was Extended One Month Yet Only Three Offerors Submitted Bids</u>

At the request of the prospective bidders, the closing date for bids was extended one month to June 13, 1972. Despite the extension, only three offerors submitted bids on the AOR 7 including National Steel and Shipbuilding Company (NASSCO), Todd Shipyards, and General Dynamics-Quincy.

The bid from NASSCO was $51,465,000. The bid from General Dynamics was $69,440,000 and the bid from Todd Shipyards (Los Angeles) was $60,603,991.

(7) <u>The National Steel Bid On The AOR 7 Was 35 Percent Lower Than That Of General Dynamics</u>

General Dynamics, builder of the first six AORs, submitted a bid almost $18 million higher than NASSCO's. In addition, Todd's bid was almost $9 million or 18 percent higher than NASSCO's. General Dynamics, capitalizing on experience with AORs 1 thru 6, detailed knowledge of the AOR 5 and 6 baseline design, plus knowledge of the AOR 7 characteristics changes, caused them to submit a bid which, in the final analysis, turned out to be closest to the final contract cost of $71.1 million.

(8) Prior To Contract Award, A Major Reporgramming Action Of $10 Million Was Requested

In September 1972, a $10 million increase was requested by the Navy to cover probably higher cost of the AOR 7. The requested increase was attributed to a stated under-estimation of material, labor and overhead costs. Approval for the $10.0 million reprogramming action was given on December 14, 1972 -- one day before the construction contract was awarded.

The allocation of these additional funds is detailed in Table E.21 below:

TABLE E.21

BREAKDOWN OF AOR 7
ESTIMATE AT REPROGRAMMING ACTION

Cost Category	FY 1972 Budget	NAVSEA Allocation of Funds	Revised Estimate
Plans	$ 1.825	$ 2.052	$ 3.877
Basic Construction	41.700	6.431	48.131
Change Orders	2.700	1.313	4.013
Electronics	.955	.130	1.085
H/M/E	1.576	1.105	2.681
NAVSEC Tasks	.250	.340	.590
Ordnance	5.019	(1.096)	3.923
Future Characteristics Changes	1.000	(1.000)	---
Escalation	1.475	.725	2.200
TOTAL	$56.500 M	$10.000 M	$66.500 M

The fact that the majority of these funds were required in the plans and basic construction areas suggests that the earlier budget-driven reductions in these areas contributed to what resulted in an overly-optimistic estimate. This reprogramming action appears to strengthen the contention by the NAVSEA estimators that the reclama figure of $56.5 million mentioned earlier was based upon arbitrary changes. It further illustrates the need for strict adherence to the requirement for budget quality estimates based on definitive design.

An additional $1.5 million was reprogrammed via OSD PBD #204 during early 1973, thereby increasing a previously reduced allowance for escalation growth. This action resulted in a revised end cost estimate of $68.0 million. These two reprogramming actions totalling $11.5 million result in an estimated end cost nearly equal to the class "D" estimate of May 1970. Had this original class "D" estimate been retained, the overrun could have been reduced by 50 percent.

(9) Best And Final Bids Were Submitted By Three Offerors On October 5, 1972

Todd Shipyards' and General Dynamics' initial bids were also their best and final. National Steel, however, did revise their bid downward from $51.72 million to $51.47 million through minor reductions in the auxiliary systems and outfitting/furnishing categories.

(10) National Steel Awarded AOR 7 Contract For $51.5 Million

On October 16, 1972, the Source Selection Advisory Council recommended the awarding of the AOR 7 contract to NASSCO. On December 15, 1972, NASSCO was awarded the AOR 7 contract for $51,474,347. The contract was a fixed price incentive type with material and labor escalation clauses. A summary of the contract costs at award follows:

Target Cost	$47,125,383
Target Profit	4,348,964
Target Price	51,474,347
Ceiling Price	58,906,727

Delivery was scheduled to be 36 months from award date.

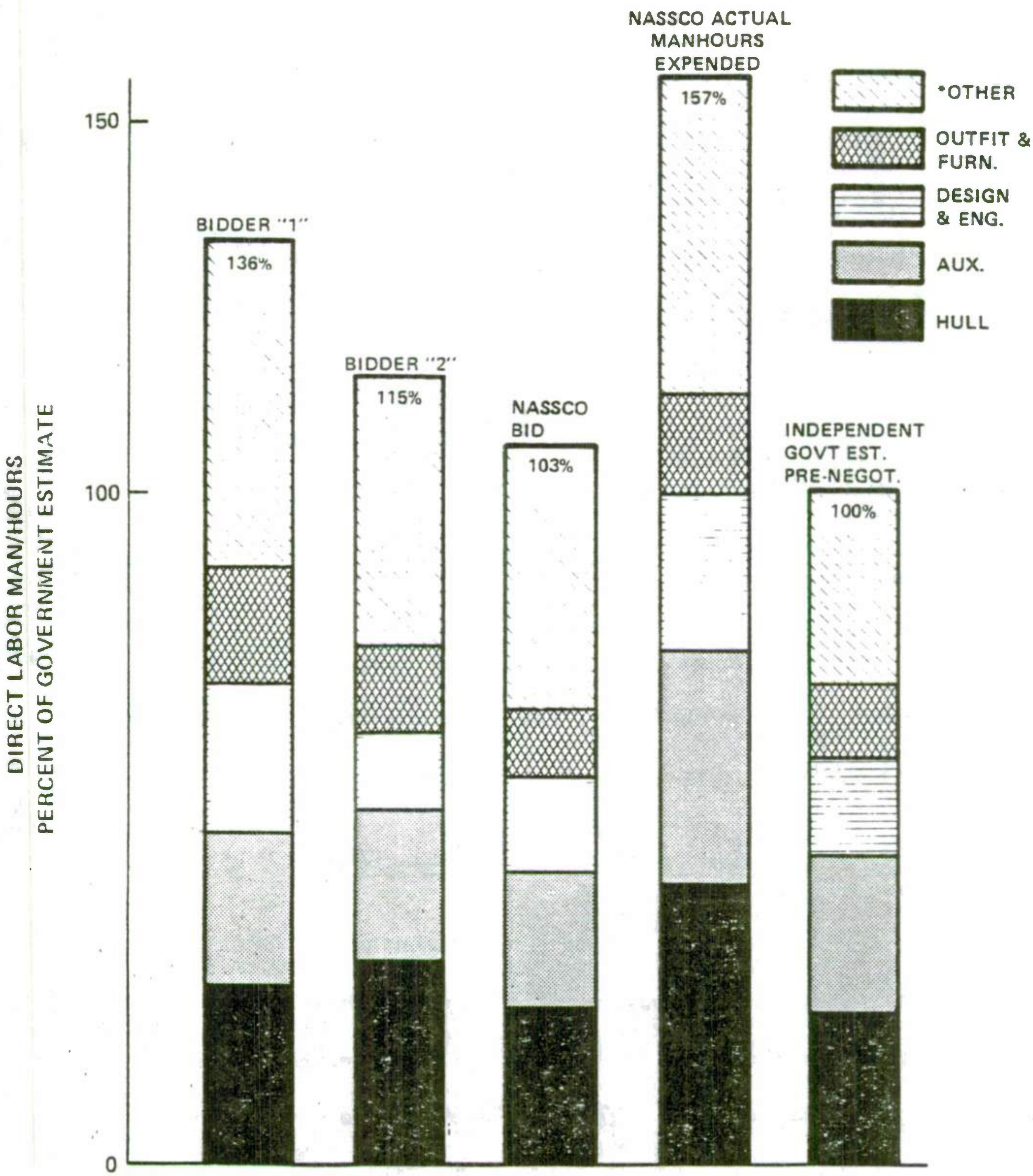
A comparison of the man-hours bid with regard to major cost categories is shown in Figure E.5 along with the Independent Government Estimate and actual man-hours expended.

(11) NASSCO's Past Performance In Meeting Delivery Dates

With respect to prior Navy ship construction, NASSCO had built and delivered twenty-four ships to the Navy since 1966. During 1963, in conjunction with the Navy, NASSCO developed the prototype combat stores ship, the U.S.S. MARS (AFS 1) and subsequently

FIGURE E.5

COMPARISON OF AOR 7 BID DATA



*OTHER INCLUDES PROPULSION, ELECTRIC PLANT, COMMUNICATION AND CONTROL AND ARMAMENT

delivered seven AFS-type ships to the Navy (the last of which delivered in 1970). This was followed by a $250 million contract for seventeen 1179 Class LSTs, the last of which was delivered in August 1972. Additionally, NASSCO had built and was still building a number of large oceangoing commercial ships. A summary of previous Navy ship deliveries reveals that of the 24 ships delivered to the Navy prior to the award of the AOR 7 contract, the contractor had averaged an overall eight months lateness in ship deliveries, five months of which were attributable to excusable delay, and three months non-excusable delay. In contrast, the other two AOR 7 bidders had an average of 23 and 15 months delivery delay, respectively, as illustrated below:

DELIVERY PERFORMANCE
1966 - 1972

AOR 7 Bidder	# of Navy Ships Since 1966	Average Months Delay	Months Excusable Delay	Months Non-excusable Delay
# 1	18	23	6	17
# 2	9	15	8	7
NASSCO	24	8	5	3

Further analysis of past NASSCO Navy ship deliveries indicated that starting with the seventh LST 1179 class ship, delivery

delay had increased to six months and thereafter increased at a rate of one month additional delay per month until the 17th and last ship of the class was delivered 14 ½ months late.

NASSCO's excusable delay (five months) was attributed to the modification and the non-excusable delay (three months) to low labor progress. This when viewed with the delays associated with the AORs 1 through 6, which averaged 16 ½ months delay -- with AOR 6 delivered 34 months late -- would indicate a certain degree of risk associated with a minimum construction period of 26 months planned for AOR 7. The table below compares the planned versus actual construction experience for the previous six AORs at General Dynamics-Quincy.

CONSTRUCTION EXPERIENCE

AOR Hull Number	Planned Construction Period (Months)	Actual Construction Period (Months)	Construction Period Overrun (Months)
1	27	40	13
2	25	40	15
3	28	38	10
4	22	34	12
5	24	21	17
6	24	58	34

NOTE: AOR 6 completion was held up by outfitting trades slowing down on the last ship in the yard.

6. AOR 7 CONSTRUCTION BEGAN ON SCHEDULE DURING OCTOBER 1973

Initially, NASSCO issued (12 February 1973) a schedule of production which provided for three months administrative lead time. This time was to be used for the preparation of bills of material and modification of drawings and plans requiring alteration to suit building methods used. This was subsequently changed to allow a nine-month lead time following determination that the original schedule was inadequate. Although NASSCO apparently allowed sufficient time to complete preparations for construction, it was found during the analysis of the contractor's eventual Request for Equitable Adjustment (REA) that NASSCO had indeed experienced overruns caused by defects in the AOR 5 and 6 construction information. After the first year, slippages began to occur in the Key Events Schedule, as shown in Table E.22.

TABLE E.22

SLIPPAGES IN AOR 7 KEY EVENTS SCHEDULE

Description	Schedule Date	Actual	Months Late
Start Construction	10/01/73	10/06/73	-
Keel	01/05/74	01/19/74	-
Launch	11/02/74	12/07/74	1
Ship Service Gen. Tests	08/01/75	05/12/76	9
Boiler Light Off	06/27/75	04/26/76	10
Preliminary Dock Trials	08/25/75	07/13/76	11
Official Dock Trials	09/08/75	07/14/76	10
Builder Sea Trials	09/29/75	08/01/76	10
Acceptance Trials	11/03/75	09/13/76	10
Contract Delivery	12/15/75	10/14/76	10

(1) Schedule Slippages Can Be Traced To Late Arrival Of Contractor-Furnished Equipment

Late deliveries impacting construction schedules occurred mostly in the main propulsion area. Late arrivals of equipment and material resulted in slippages in the Master Machinery Erection (MME) Schedule events of from three to 12 months. Examples of the above are found in Table E.23.

TABLE E.23

AOR 7 MME SCHEDULE SLIPPAGE

MMEs No.	Description	Scheduled Date	Actual
2C	Pumps, Fire	02/15/74	04/23/75
2D	Pumps, Main Feed	04/12/74	12/03/75
2E	Pumps, Main Condensate	04/26/74	12/20/74
2F	Pumps, Main Circulating	05/17/74	01/07/75
6	Generators, Emergency Diesel	04/19/74	12/16/74
7	MG Sets 30 KW, 400 HZ	04/19/74	02/06/75
8	Compressor, Air	04/29/74	05/01/75
11	Condensers, Main	05/17/74	09/19/74
12A	Main Propulsion Turbines	05/25/74	09/23/74
12B	Main Propulsion Red. Gears	05/24/74	09/20/74
13	Distilling Plant	05/24/74	12/13/74
14	Tanks, DA Feed	05/31/74	05/01/75
15A	Switch Board Main I.C.	06/07/74	08/23/74
15B	Switch Board S/S	06/06/74	09/18/74
15D	Switch Board Emergency	06/28/74	09/06/74
16	Boilers, Main	06/14/74	11/02/74
18	Forced Draft Blowers	06/28/74	10/31/74
19	Steering Gear	06/28/74	09/25/74
9	Generators SS	05/03/74	02/12/75

- Boiler light-off was ten months behind schedule primarily due to slipped hull erection schedules and delivery of critical valves. A summary of the scheduled and actual delivery dates for key valves are found in Table E.24.

- Due to non-receipt of valves, the contractor proposed on 17 December 1975 that the current contract delivery date of 15 July 1976 could only be met if Navy approved the substitution of commercially-available replacements. Following discussions regarding valve substitution, the contractor advised on 22 January 1976, that barring unconditional approval for valve substitutions, the delivery date would slip to 30 September 1976. (Approval was denied.)

TABLE E.24

AOR 7 VALVE SCHEDULE SLIPPAGES

Item	Scheduled Delivery	Actual Delivery
Fire Main Valves, Main Deck & Below	07/03/74	02/03/75
Drain Valves, Engine Room	05/20/74	04/21/75
High Pressure Desuperheat Steam Valves	07/05/74	04/09/76
Fuel Oil Mainfolds	05/03/74	12/16/75
Fuel Oil Stripping Valves	05/03/74	12/16/75
Gland Seal & Exhaust Valves	07/15/74	06/26/75
Gland Exhauster Valves	07/22/74	06/05/75
150 # Steam Valves	06/03/74	06/25/75
150 # Steam Valves	06/03/74	02/02/76
Boiler Blow Valves	07/29/74	10/29/75

(2) Key Event And Master Machinery Erection Schedule Slippages Necessitated Extensive Work-Arounds And Resulted In Deviations In Planned Direct Labor Expenditures

The majority of deviations in planned direct labor expenditures came before launch when massive efforts were initiated to meet launch date, which was accomplished within one month of original schedule. Figure E.6 illustrates the magnitude of changes in planned manpower scheduling. Figure E.7 which follows indicates the magnitude of other work in the contractor's yard and might explain the rigid adherence to the planned AOR 7 launch date.

FIGURE E.6

SCHEDULE MANPOWER LOADING vs. ACTUAL MANPOWER LOADING

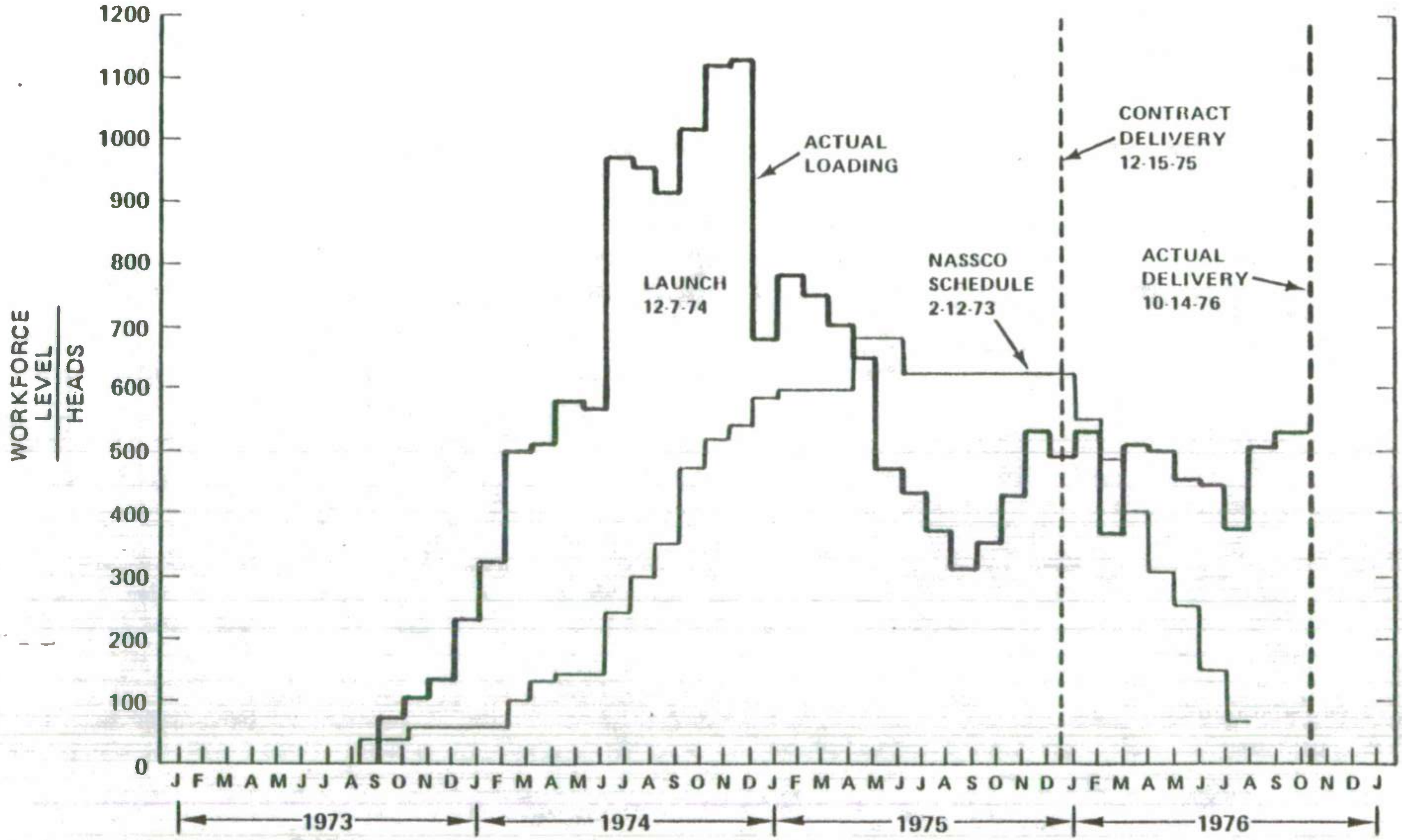
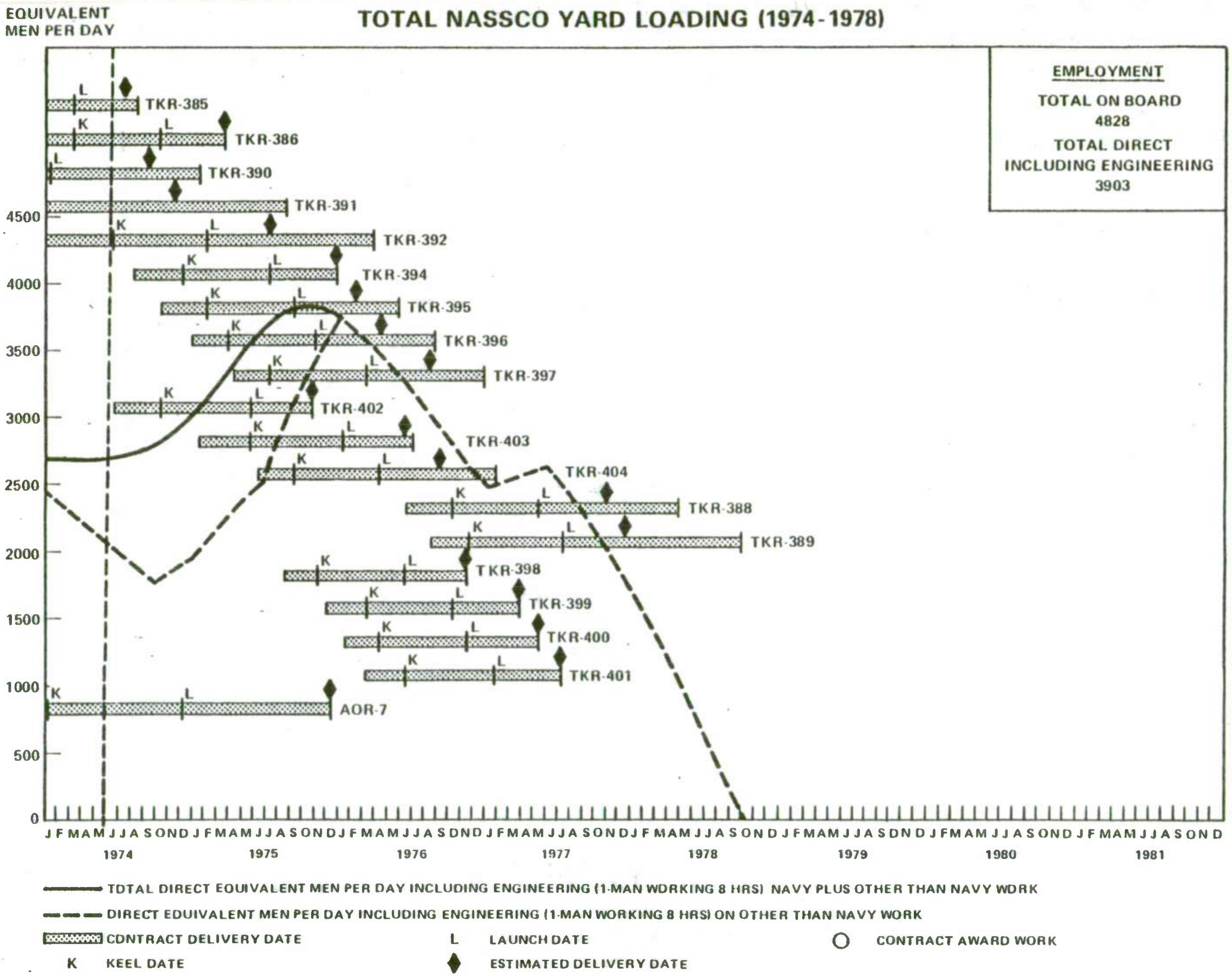


FIGURE E.7



SOURCE: NAVSEA DSP (JUN, 1974)

(3) Excess Manpower Expenditures Indicate Low Productivity And Defective Plans And Drawings

The total man-hours expended exceeded the NASSCO bid amount by nearly 1.7 million, of which 938,000 or 55 percent can be traced to the area of hull construction. An additional 467,000 man-hours is attributed to overruns in the auxiliary systems and construction services categories. NASSCO's stated reasons for the labor overrun experienced in AOR 7 included defective prior ship construction information which was not representative of the actual configuration of the AOR 5 and 6, unanticipated work resulting from government changes in nine major areas, and non-incorporation of Advance Engineering Authorizations which the contractor felt were known to the Government, but which were not supplied with other government furnished construction information.

It is interesting to note that all three bidders plus the government estimators were found to have estimated nearly one million man-hours less than was actually necessary to complete the hull structure. In addition, the builder of the AORs 1 through 6 was approximately 20 percent below total actual man-hours expended. A comparison of total man-hour estimates was shown previously in this chapter in Figure E.5 which is found on page E-82.

Analysis of the documentation available covering settlement of the Request for Equitable Adjustment shows that part of the reason for the large labor overrun is attributed to the use of inadequate or defective prior ship construction information. This is supported by NASSCO's allegation that the drawings supplied from the AOR 5 and 6 which they were contractually required to use in constructing the AOR 7, were not in an "as built" condition. In this connection, various measurements and photographs that had been taken aboard AOR 5 and compared with the related drawings supported these allegations. Evidence of massive space interferences and apparent non-incorporation of Advance Engineering Authorizations in the AOR 5 drawings resulted in the contention that the drawings supplied (GFI) did not reflect the actual prior ship configuration. The Government's own analysis of the REA stated that the five day period allowed bidders for review of some 1500 plans and drawings was not adequate for a determination of completeness. More than 200,000 man-hours were allowed NASSCO via settlement of their REA for engineering, production and disruption as a result of the inadequacies found in construction drawings.

A comparison of the bid estimates, both from government and builders shows that in the category of hull structure NASSCO's

estimate of man-hours equalled only 37 percent of the actual hours expended, Navy's independent estimate amounted to only 34 percent of actual expenditures, and General Dynamics' estimate (after building six AORs) was only for 45 percent of the actual man-hours required for hull completion. The fact is that none of the estimates, regardless of the amount of expertise shown by the estimators, fell within two-thirds of the actual man-hour expenditures in the hull construction category. It should be noted that the hull category accounts for approximately one-third of the total man-hours expended and represents approximately 50 percent of the total man-hour overrun. This appears to point to the possibility of a gross miscalculation of achievable productivity especially in the area of hull construction. This is supported by the government's own analysis of NASSCO's REA, in which it was stated that NASSCO's bid contained a reasonable man-hour estimate.

While there appears to be no single factor that accounts for the excessive man-hour expenditures from the available data it can be assumed that a combination of factors contributed to the overage. These include defective prior plans and drawings, low productivity in the hull construction area and additional man-hours charged to the auxiliary systems area which are attributable to late CFE and the

resultant work-around and catch-up expenditures. Actual man-hour percentage variations are shown in Table E.25 below. As seen below actual total man-hour expenditures exceeded the bid estimate by 71 percent and the Government's independent estimate by 76 percent.

TABLE E.25

NASSCO BID/GOVERNMENT VS. ACTUAL MAN-HOURS PERCENTAGE VARIATION BY CATEGORY

	NASSCO % (+) (-)	Government % (+) (-)
Hull Structure	+ 171	+ 197
Propulsion	+ 33	+ 60
Electric Plant	- 4	- 5
Communication & Control	- 21	+ 65
Auxiliary Systems	+ 44	+ 29
Outfitting and Furnishing	+ 39	+ 7
Armament	+ 147	- 66
Design & Engineering Services	+ 55	+ 60
Construction Services	+ 61	+ 108
Total Man-hour Overrun %	+ 71	+ 76

(4) Government-Furnished Equipment Was Not A Significant Factor Impacting Construction Delay Or Contract Growth

Late GFE was not considered a contributing factor to either delivery delay or shipbuilder's cost growth based on the approved, revised delivery date. Installation of the NATO SEASPARROW Surface Missile System (NSSMS) could have been a factor, but this was

stopped or deferred by HMR 53 (dated January 1975) and subsequently accomplished during the post-delivery period at Long Beach Naval Shipyard. Such action probably averted a significant claim. The AOR 7 was delivered with an ordnance installation that consisted of two guns which, while prudent from a claims point of view, represented the loss of a planned defensive capability at delivery and, in fact, was necessitated by a major slippage in the NATO SEA-SPARROW weapons system.

The subsequent cost impact of this deferral was an overrun of $0.7 million, the majority of which ($0.5 million) was in the cost of the launcher and director. A summary of the events which lead to deferral of the NSSMS follows:

- Decision to include NSSMS in AOR 7 characteristics was approved by OPNAV in July 1971.
- NSSMS estimated hardware delivery dates began to slip as early as August 1973.
- NASSCO advised in January 1974 of three month NSSMS delivery delay.
- In November 1974, SupShips advised that delivery of AOR 7 with operable NSSMS was highly improbable.
- In December 1974, NAVSEA recommended to OPNAV that NSSMS be placed in space and weight category with installation deferred to FOA.
- CNO approved NSSMS change in January 1975.

(5) Delivery Of The AOR 7 Was Delayed Ten Months

All delay was adjudicated as excusable in contract modifications with actual delivery taking place on 14 October 1976 vice the originally scheduled date of 15 December 1975.

- In January 1975, the contractor affirmed 15 December 1975 as the then current contract delivery date.
- Contractor, in mid-February 1975, asserted that ship would be delayed as a result of stated causes, primarily late CFE, which he considered excusable and proposed that 15 April 1976 be accepted as the guaranteed delivery date of the ship.
- Government rejected proposed new guaranteed delivery date on the grounds that stated causes were present prior to early January 1975 when the contractor reaffirmed the 15 December 1975 delivery date.
- The Government, by contract modification dated 21 July 1975, agreed to extend the delivery date of 15 December 1975 to 15 June 1976 for stated considerations, which included full and final settlement for all claims arising out of delays in delivery of GFE (Schedule A) which previously occurred. The considerations did not include late GFI.
- Government, by contract modification dated 17 September 1976, agreed to extension of contract delivery date to 14 October 1976.
  - Considerations included contractor acceptance of full responsibility for cost of additional Builder Trial held during August and September 1976.

- Contractor further ogreed to correct certain government-responsible trial item deficiencies as per attachment to FMR 88.

(6) Final Adjudicated Contract Price Was $71.1 Million (End Cost $86.3 Million)

Over the life of the AOR 7 controct, o total of $900 thousand was paid to NASSCO for adjudicated changes reflected in FMRs and HMRs. By contract modification, the controct billing price was increased to cover allowoble cost increoses reloted primarily to increased labor expenditures for o totol of $6.7 million. Table E.26 summarizes the contract cost growth.

TABLE E.26

SUMMARY OF AOR 7 CONTRACT COST GROWTH

Originol Contract Target Price	$51.4
FMRs ond HMRs lexcluding REA-reloted)	.9
Increased Billing Price via Controct Modification	6.7
HMR # 58 (REA settlement)	2.9
Escalotion Paid	9.2
Final Adjudicated Contract Price	$71.1 million

The majority of the finol cost increase wos incurred os a result of the settlement of a Request for Equitoble Adjustment (REA) submitted by NASSCO in November 1975. The originol REA totalled over $20 million and contained 19 separote items. The settlement

negotiations are outlined below:

- The REA was examined by a team from SupShips-San Diego in order to analyze the facts and aid settlement.

- In October 1976, the original REA was formally modified to nine items as follows:

Replenishment-at-Sea	$ 748,893
Hotel Space Arrangement	2,698,654
Machinery Spaces Interferences	1,595,997
Growth in Electrical Dist.	278,756
Degaussing Systems	22,647
Pollution Holding Tanks	116,833
Thermal Insulation	65,647
Shafting Calculation	34,420
Grounding of Elect. Equip.	28,877
	$5,590,724

- Subsequent technical and cost evaluations substantiated that NASSCO had incurred reimbursable costs as a result of Government changes and defective ship construction plans and drawings.

- Following review, the Government proposed a settlement of $2.9 million. Extensive negotiations took place between NASSCO and Government representatives and agreement was reached on November 12, 1976, in the amount of $3.5 million. This included $581 thousand for outstanding FMRs (repairs to GFM, etc.) and $2,919,000 covering items specified in the REA. Details regarding the $2.9 million settlement are found in Table E.27.

- The $9.180 million escalation paid ($4.017 million related to labor and $5.163 million to materials) equals approximately 40 percent of the total contract growth. The escalation provision had reached the maximum permitted number of quarterly payments eleven months prior to delivery. The approved budget baseline allowed for only $1.475 million for

TABLE E.27

DETAIL OF SETTLEMENT OF AOR 7 REA

Reference	Items	Actual Settlement
HMR -	Replenishment-at-Sea	$ 387,487
58.1	Habitability	1,346,985
58.2	Machinery	814,995
58.3	Electronics Growth	44,495
58.4	Degaussing	6,845
58.5	Holding Tanks	17,306
58.6	Insulation	23,939
58.7	Shafting	19,899
58.8	Grounding	11,197
	HMR SubTotal	$2,673,148
	Profit	245,930
		$2,919,078

escalation growth. The most significant increase in escalation results from revisions in the rates upon which the escalation payments are computed. This amounted to a $4.331 million adjustment to the escalation funds as reported in the August 1974 Ship Cost Adjustment Report.

7. THE UNESCALATED COST GROWTH EXPERIENCED IN THE AOR 7 ACQUISITION IS PRIMARILY ATTRIBUTABLE TO AN UNDERESTIMATE OF MANPOWER REQUIREMENTS

Analysis of available data shows that the overrun in labor costs occurred as detailed below.

(1) Construction Plans For The AOR 7 Were Inadequate And Defective

The contract required that the detail working drawings prepared for the AOR 5 and 6 by General Dynamics-Quincy be utilized to the maximum extent possible for the AOR 7. The offerors were given only five days during which time they were to evaluate some 1,500 drawings and plans. Although bids were based upon this information, it is improbable that a complete review could have been possible considering the time available.

The contractor expended an unanticipated amount of labor for engineering the necessary changes to drawings and plans from the AOR 5 and 6. This additional effort had the effect of disrupting other scheduled work since plan schedules were not met, as illustraded in the following table.

A review of the documentation of HMR #58 indicates that approximately $2.7 million was granted the contractor for excess

TABLE E.28

AOR 7 DRAWINGS
Schedule and Progress Record

Drawing Title	Issue Scheduled	Issue Actual
Vent, 01 & 02 Level - Fdn.	08/02/74	10/14/74
Fdn., Electrical, Fire Room	05/17/74	11/08/74
Diag. Main Steam System	05/04/73	11/14/73
Diag. Main Steam & Condenser System	08/10/73	12/07/73
Boiler Feed Piping	03/29/74	06/26/74
LP Boiler Feed Piping	04/26/74	06/10/74
Aux. S.W. Cooling Piping, Fire Rm.	04/19/74	06/11/74
Fuel Oil Boiler Front Piping	04/19/74	06/10/74
Lube Oil Transfer & Purifying Piping	03/15/74	08/30/74
Pwr. System WDP Fire Room, 11-6 and 15-6 Levels	06/14/74	09/28/74
Diag. JP-5 Cargo System	04/06/73	07/10/73
Diag. NAV Distillate Cargo System	04/06/73	07/10/73
Aft Sewage Disposal Room	04/15/74	07/29/74
Amidships Sewage Disposal Room	04/15/74	08/07/74
Forward Sewage Disposal Room	04/15/74	08/21/74
Fire Main Piping - Fire Room	04/19/74	06/21/74
Diag. Aux. Machinery and S.W. Circ. System	-	04/08/74

labor necessitated by government-responsible inadequacies and defects regarding construction plans and drawings.

(2) Contractor-Furnished Equipment Was Constantly In Overdue Status

A review of available progress documents shows that the overdue status of contractor-furnished materials/equipment adversely impacted planned key event and erection schedules.

- Only nine of the 43 events scheduled for completion during the period October 1973 through July 1974 were completed as scheduled.

- The contractor advised on 28 January 1975 that the scheduled ship delivery date of 15 December 1975 was unattainable due to late CFE and unreceived material items. In February 1975, proposed delivery on 15 April 1976 because of approximately 2,000 specific line items of late material.

- Due to non-receipt of valves (some of which were critical to boiler light-off), the contractor proposed on 17 December 1975 that the then current delivery date of 15 July 1976 could only be met if Navy approved the substitution of commercially-available replacement valves. Following discussions regarding the above, the contractor advised on 22 January 1976 that, barring unconditional Government approval for valve substitutions, the delivery date would slip to 30 September 1976. (Approval was denied.)

- As of April 1976, 260 items of CFE still had not been received although the 14 valves critical to boiler light-off were then available, somewhat easing the probability of further disruption. It should be noted that a 30 September 1976 delivery date was still

projected at this time, although actual delivery was two weeks later.

8. THE AOR 7 EXPERIENCED AN OVERRUN OF 53 PERCENT ON THE ORIGINAL BUDGETED END COST ESTIMATE FORWARDED TO THE CONGRESS IN 1971

Program tracking was able to identify an aggregate overrun of $29.8 million during the six year period from authorization to ship delivery. Several areas contributed to the overall cost growth.

- Cost attributable to basic construction accounted for 66 percent ($19.7 million) of the growth caused by

  - Incorrect plans
  - Defective specifications
  - Inadequate time to estimate
  - Changing market conditions
  - Low productivity
  - Delay in government action
  - Scheduled event delays

- Costs in other areas including escalation, changes and GFE/GFI accounted for the remaining $10.1 million related to:

  - Constraints on estimates
  - Program uncertainty
  - Unanticipated escalation
  - Low productivity
  - Insufficient definition
  - Characteristics changes
  - Incorrect plans and defective specifications
  - Poor estimates
  - Inadequate time to estimate

9. CONCLUSIONS

The tracking leads to the following conclusions relative to the AOR 7 experience.

- The numerous pre-authorization budget reviews caused a pressuring of the estimating process which resulted in lower estimates.
- Budget ceilings, real or self-imposed, seriously inhibited allowances for reasonable contract growth especially as seen in the overrun in escalation.
- Budgeting decisions were made without budget quality estimates and characteristics changes were made during the contract design process, thus invalidating the budgeted amount. (See Table E.29.)
- Completed prior ship drawings were not updated in a systematic or disciplined manner.
- The time allowed to review AOR 5 and 6 working drawings was not adequate and provisions to ship check AOR 5 and 6 for "as-built" conditions were not made.
- AOR 7 characteristics changes were used as a wedge for inflating or deflating end cost estimates. The cost impact of these changes was underestimated.
- Productivity factors were in error.
- CFE lead times were inadequate.
- NAVSEA did not adequately react to several indications that NASSCO had underbid by a substantial amount when compared to the bids submitted by both the builder of the AORs 1 through 6 and Todd Shipyards.
- Lack of an adequate budget quality ("C") end cost estimate for a modified repeat design cannot be justified.

TABLE E.29

SUMMARY OF AOR 7 COST MOVEMENT

Cost Category	$68.5 Million Class "D" May 1970	Reductions	$56.5 Million Class "F" Nov. 1970	Final Estimate Oct. 1976
Plans	1.880	(.055)	1.825	3.527
Basic Construction	44.700	(3.000)	41.700	61.425
Change Orders	3.600	(.900)	2.700	2.313
Electronics	1.145	(.190)	.955	.985
H/M/E	1.790	(.214)	1.576	2.190
NAVSEC Tasks	1.000	(.750)	.250	1.098
Ordnance	8.055	(3.036)	5.019	5.000
Future Char. Changes	1.700	(.700)	1.000	.456
Escalation	4.630	(3.155)	1.475	9.306
Total	$68.500	$(12.000)	$56.500	$86.300

IV. CASE STUDY OF THE SSN 678

This class of nuclear attack submarines has as its mission the locating and destruction of enemy submarines and surface ships. They are designed to conduct radio, radar and sonar reconnaissance, as well as coordinated anti-submarine warfare units. It is the largest single class of nuclear powered submarines in the fleet. The acquisition for the 37 ship class covered a period of fourteen years from the award of the first contract for SSN 637 in November 1961, to the commissioning of the SSN 687 in August 1975.

This chapter will trace, in part, the acquisition of the 37 ships of the STURGEON Class of nuclear attack submarines and, in detail, the ARCHERFISH SSN 678 (the 24th ship) from the original end cost estimate as submitted to the Congress through contract award, construction and delivery. The original end cost estimate for the SSN 678 forwarded to Congress in 1966 was $341 million for a buy of five FY 1967 ships or an approximate $70 million estimated per unit end cost. A construction contract for four ships was awarded to the Electric Boat Division of General Dynamics in June 1968, including the ARCHERFISH which was delivered to the Navy three months ahead of schedule on 23 December 1971, at an estimated end cost at delivery of $84.3 million. This amount represents an apparent cost growth of approximately 20 percent.

1. THE DEVELOPMENT OF THE STURGEON CLASS SUBMARINE WAS EVOLUTIONARY RATHER THAN A MAJOR DEPARTURE FROM PREVIOUS DESIGNS

Modern nuclear-powered attack submarines have actually followed a developmental path which began with the SKIPJACK, thence to the THRESHER/PERMIT Class, thence to the STURGEON Class, and finally to the current LOS ANGELES Class. The STURGEON Class design was founded on the improved depth and silence capabilities of the THRESHER/PERMIT Class. The need for immediate incorporation of designated SUBSAFE requirements hastened this development process in the case of the STURGEON Class.

Guidance for updating the characteristics was orderly throughout the long acquisition program and closely paralleled the state of the art in electronics and weapons development. Changes were almost continuous as is seen in the Characteristics Chronology set forth in EXHIBIT E.5 which is found on page E-331.

Highlights of the evolution of the class follow:

- The first eleven submarines (FY 1962-1963) were originally planned to be PERMIT (SSN 594) Class ships. The first three FY 1962 ships were awarded in November 1961 as PERMIT Class ships and were subsequently modified and redesignated as STURGEON Class ships.
- In December 1961, a re-engineering of the PERMIT Class design was ordered which included:

- System simplification
- Improvement based on fleet experience
- Improved military characteristics
- SUBSAFE retrofits

- The design changes were considered to be of such magnitude as to warrant designation of a new class of submarine, the STURGEON Class, which was approved in October 1962.

- The requirement for 37 STURGEON Class ships was not documented at the outset, rather the requirement evolved during the progression of annual programs.

The ships in the SSN 637 Class were authorized by Congress in Fiscal Years 1962 through 1969 as shown in the following table:

TABLE E.30

SSN 637 CLASS PROCUREMENT SCHEDULE

Fiscal Year	62	63	64	65	66	67	68	69
No. Authorized	3	8	5	6	6	5	2	2

The FY 1962 SSNs were awarded to General Dynamics, Electric Boat Division (lead ship) and one follow ship each to Ingalls Shipbuilding and General Dynamics-Quincy. During the eight fiscal years of SSN 637 Class procurement, all contracts were awarded on a competitive basis except for the seven ships built in naval shipyards.

Contracts from FYs 1962 through 1965 were fixed price. Fiscal Year 1966 contracts, also fixed price, added a special provision for an early delivery bonus, a feature which carried through the remaining program years.

In addition, the FY 1967 through 1969 contracts were fixed price incentive fee types which offered shipbuilders a share of the savings realized by under-running a contractually specified target for incurred costs.

(1) Over The Entire Thirty-Seven Ship Program Actual Costs Exceeded Predicted Costs By 13.1 Percent With An Average Delay Of About 13 Months

Over the nine year period during which SSN 637 Class submarines were constructed, the average cost per ship was $76.5 million. An initial cost growth in the FY 1962 buy is attributed to SUBSAFE requirements and associated design changes brought about by the U.S.S. THRESHER accident in 1963. Table E.31 indicates the resulting cost growth totalling $41.1 million for the three FY 1962 ships. SUBSAFE changes contributed about one-third of this cost growth with the associated design changes accounting for the remainder.

TABLE E.31

SSN 637 CLASS - COST GROWTH OF FY 1962 SHIPS
(Dollars in Millions)

Hull No.	FY	Budget Est. To Congress	End Cost	% Growth	Contract Deliv. Date	Actual Deliv. Date	Months Late	Building Yard
SSN 637	62	61.3	70.4	14.8	9/65	3/67	18	Electric Boat
SSN 638	62	61.3	70.8	15.5	7/65	8/68	37	GD-Quincy
SSN 639	62	61.3	83.8	36.7	4/65	8/68	40	Ingalls
		183.9	225.0	22.2				

The program estimates and actual costs for the entire program are shown in the following table.

TABLE E.32

SSN 637 CLASS COST HISTORY OVER PROGRAM
(Dollars in Millions)

Approved Congressional Budget vs. Actual End Cost

Fiscal Year	Number of Ships	Approved Budget	Budget Cost Per Ship	End Cost	End Cost Per Ship	Cost Variance by Fiscal Year
62	3	183.9	61.3	225.0	75.0	41.1
63	8	505.9	63.2	612.4	76.6	106.5
64	5	337.3	67.5	363.9	72.8	26.6
65	6	441.0	73.5	426.5	71.1	(14.5)
66	6	400.9	66.8	437.2	72.9	36.3
67	5	341.0	68.2	396.6	79.3	55.6
68	2	143.2	71.6	176.0	88.0	32.8
69	2	162.6	81.3	196.4	98.2	33.8
		2,515.8		2,834.0		318.2

An overall cost growth of $318.2 million or approximately 13 percent has been experienced in the SSN 637 class. Additionally, claims totalling approximately $200 million have been filed and are still outstanding. However, it should be pointed out that this nominal cost increase supported a program which accommodated a systematic update of class characteristics which resulted in delivering highly capable units to the fleets. The diversity of these characteristic changes is summarized in Figure E.8.

Delivery delays averaged 13.1 months over the acquisition period. Electric Boat Division - General Dynamics built 32 percent of the program's ships and experienced no overall delay. On average they better delivery dates by one month. Table E.33 illustrates program delivery performance.

TABLE E.33

SSN 637 CLASS DELIVERY DELAYS

FY	Electric Boat		NNSDDC		Quincy		Ingalls		Mare Island		Portsmouth	
62	(1)	+1	-	-	(1)	+14	(1)	-	-	-	-	-
63	(1)	+5	(2)	+4	(1)	+16	(3)	+2	-	-	(1)	+9
64	-	-	(3)	+3	-	-	-	-	(1)	-	(1)	+11
65	(2)	+3	(2)	+4	-	-	-	-	(2)	+33	-	-
66	(4)	-16	-	-	-	-	-	-	(2)	+38	-	-
67	(3)	-9	-	-	-	-	(2)	-	-	-	-	-
68	(1)	-13	-	-	-	-	(1)	+1	-	-	-	-
69	-	-	(2)	-2	-	-	-	-	-	-	-	-
Total	(12)	-29	(9)	+9	(2)	+30	(7)	+3	(5)	+71	(2)	+20
% of Class		32		25		5		19		14		5
Average Delay (Mos.)		-2.4		+1		+15		+0.4		+14.2		+10

NOTE: Number of ships indicated by parentheses ( ).
+ indicates months of delay by yard and by fiscal year.
- indicates months ahead of schedule by yard and by fiscal year.

The private contractors, General Dynamics/Electric Boat and Newport News Shipbuilding and Drydock, had enviable delivery records as indicated by Tables E.33 and E.34.

TABLE E.34

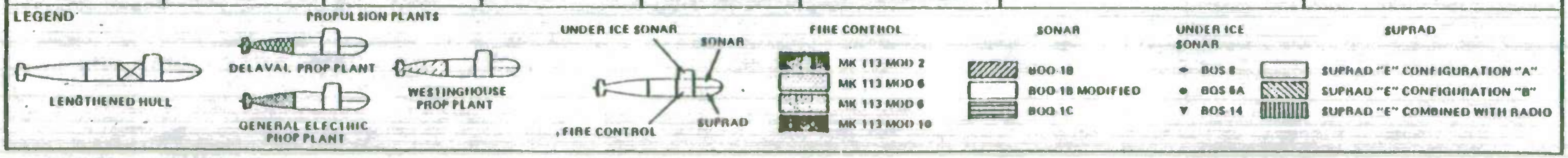
SSN 637 CLASS BUILDING PERIODS
(Award to Delivery)

Shipyard	Number Of Ships	Average Months Per Ship
Electric Boat - Groton	12	52
General Dynamics - Quincy	2	77
Newport News	9	54
Ingalls	6	71 (less POGY)
Mare Island - NSY	5	72 (incl. GUITARRO)
Portsmouth - NSY	2	90

These deliveries took place during a period of evolutionary design changes in the class. Schedule A's (Government Furnished System/Equipment/Component Listing) were constantly updated to reflect technological progress and changes in military characteristics which were routinely incorporated over the program years. A major re-design (hull lengthening) took place in the FY 1967 buy -- of which the SSN 678 was the first in this modified design. Figure E.8 illustrated the sequential incorporation of changes over the span of the 37 ship program. Note the hull lengthening, Schedule A update, mid-ships compartment rearrangement and other changes that were incorporated into the ships of the FY 1967 and FY 1968 programs.

FIGURE E.8

SHIPYARDS	FY 1962	FY 1963	FY 1964	FY 1965	FY 1966	FY 1967 / FY 1968	FY 1969
	MOD 1, 2 & 3 BASIC SPECIFICATION	MOD 1, 2, & 3 BASIC SPECIFICATION	MOD 4 DELAVAL PROPULSION PLANT & MAIN CONDENSER COMBINATION NEW SCHEDULE "A"	MOD 5 SONAR CHANGES BQS 13 REPLACED BQS 6 BQS 14 ADDED NEW SCHEDULE "A"	MOD 6, 7 & 8 AIR COND PLANT CHANGE GENERAL ELECTRIC PROPULSION PLANT WITH DELAVAL MAIN CONDENSER PARTIAL ENGINE ROOM MOCK UP NEW SCHEDULE "A"	MOD 9, 10, 11 & 12 NEW SCHEDULE "A" HULL LENGTHENING NOISE REVIEW PROGRAM COMBINED ECM/RADIO ROOM COMBINED LP BLOW/DIESL GEN EXHAUST MIDSHIPS COMPARTMENT REARRANGEMENT DSRV MODIFICATIONS 18D PERISCOPE	MOD 13 NEW SCHEDULE "A"
E.B. DIVISION	637	650		667 669	673 674 675 676	678 679 681 684	
BETHLEHEM	638	649					
INGALLS	639	648 652				680 682 683	
PORTSMOUTH		646	660				
NEW YORK SHIP		647					
NEWPORT NEWS		651 653	661 663 664	668 670			686 687
MARE ISLAND			662	665 666	672 677		



TOTAL — 37 SHIPS

2. THE SSN 678 GREW IN COST OVER THE BUDGETED AMOUNT BY 20 PERCENT, BUT WAS DELIVERED AHEAD OF SCHEDULE

The history of the SSN 678 procurement was, from all indications, based upon a fairly realistic estimated end cost and was part of a well-managed procurement program. The historical performance by General Dynamics - Electric Boat Division coupled with an incentivized contract, appears to have impacted favorably upon actual delivery time.

(1) Five SSNs Were Authorized For The FY 1967 Program At A Total $341.0 Million Estimated End Cost

The CNO requested a price-out for the FY 1967 SSNs during September 1964. This request resulted in an October 1965 estimate of $68.2 million average cost per ship based upon the characteristics of the FY 1966 SSN 637 Class ships. This estimate was forwarded to OSD for inclusion in the FY 1967 budget.

In March 1966, however, CNO directed NAVSEA to undertake a study relative to the inclusion of additional space and weight for the Acoustic Information Gathering System (AIGS). The findings of this May 1966 study showed that the then-current length of the ship's hull would have to be increased by eight feet, which, for the five FY 1967 ships would add an estimated $3.7 million. This additional funding requirement was to be provided through a combination

of Future Characteristics Change money ($1.3 million) and cost reduction from the deletion of some previously planned equipment changes.

September 1966 saw the initial submission of the revised characteristics for the FY 1967 ships to members of the Ships Characteristics Board. These were approved in February 1967 and included changes for Acoustic Information Gathering System (AIGS), noise goals, installation of a Tactical Range Pinger, increased accommodations and various electronics alterations. The evolution from the initial price-out to budget baseline ship is detailed below for the SSN 678 ARCHERFISH.

TABLE E.35

BUDGET ESTIMATE CHANGES
(dollars in millions)

DATE		REMARKS
October 1965	$68.2	Price-out per CNO request
May 1966	$68.9	Increase for lengthening hull by eight feet
September 1966	$70.0 (Budget Baseline Ship)	FCC reserves for additional characteristics

The original end cost estimate forwarded to Congress in 1966 for the SSN 678 was $70.0 million, and was included in the FY 1967 SSN 637 class budget request for five ships. A summary of the approved budget for the SSN 637 (FY 67) follows:

.	SSN 678	$ 70.0 million
.	SSN 679	70.0
.	SSN 680	67.0
.	SSN 681	67.0
.	SSN 682	67.0
	Total	$341.0

(2) The First Major Adjustment To The Approved Budget Baseline Ship Resulted From Numerous Approved Characteristics Changes

The approved cost for SSN 678 of $70.0 million included $31.5 million for basic construction. Although detailed documentation has not been available, an increase of over $7 million in the area of basic construction was experienced between budget approval and contract award with an additional $1.5 million increase thereafter. The indications would tend to support a conclusion that the greatest portion, if not the entire amount, can be directly related to the required changes in the ship's configuration brought about by the hull-lengthening and other interior rearrangements. Accumulated pre-award changes in the end cost estimate for SSN 678 are summarized in Table E.36.

TABLE E.36

CHANGES IN END COST ESTIMATE -- SSN 678
BETWEEN CONGRESSIONAL APPROVAL AND CONTRACT AWARD
(Dollars in Millions)

Congressional	70.0
May 1966 -- New Cost for Sonar	0.8
August 1966-68 -- hull lengthening, etc.	8.5
September 1967 -- (SCA Review)	1.0
Estimated End Cost at Award	80.3

It should be noted from the above, that approximately 70 percent ($10.3 million) of the actual cost growth at delivery ($14.3 million) was apparent at the award date.

(3) The Independent Government Estimate Was $4.4 Million Less Than The Negotiated Contract Price

Estimates dated 4 March 1968 projected that each of the FY 1967 submarines in a four-ship buy would cost $34,066,000 (shipbuilder's price) while the negotiated contract price of 25 June 1968 totalled $38,500,000. Details with respect to these projected costs follow:

Item	Independent Gov't. Est.	Awarded Contract	Estimate Over/(Under) Award
Direct Labor Hours	3,908,600	3,492,975	415,625
Direct Labor Dollars	$13,271,000	$13,925,297	$ (654,297)
Direct Material Dollars	10,060,000	8,693,770	1,366,230
Overhead	(68.5%) 9,091,000	(93.5%) 13,023,687	(3,932,687)
Total Construction	$32,422,000	$35,642,754	$(3,220,754)
Profit	(5.07%) 1,644,000	(8.02%) 2,857,246	(1,213,246
Total Projected Cost/Ship	$34,066,000	$38,500,000	$(4,434,000)

The factors which appear to have affected this estimate result from the underestimating of overhead percentages, direct labor wages, and profit. The basis for the Government's independent estimate was stated as the "average labor hours, labor rates, material costs, overhead percentages and profit from prior year SSN procurements". In the case of Electric Boat and other shipyards heavily engaged in Navy work, closer estimates of wages and overhead could be developed if a more thorough analysis of audit, progress payment, and similar data was made. From data in the preceding table, differences of 15 percent in wage rate assumption and of 30 percent in assumed overhead dollars can be derived as shown by the following calculations.

	Independent Govt. Est.	Awarded Contract
$\frac{\text{Direct Labor Dollars}}{\text{Direct Labor Hours}}$	$\frac{\$13,271,000}{3,908,600} = \$3.395$	$\frac{\$13,925,297}{3,492,975} = \$3.987$

$$\begin{array}{r} \$3.987 \\ -3.395 \\ \hline 0.592 \end{array} \qquad \frac{\$3.987}{0.592} = 14.8\%$$

$$\frac{\text{Overhead Difference}}{\text{Overhead Awarded Contract}} \qquad \frac{\$3,932,687}{13,023,687} = 30\%$$

(4) A Contract Was Awarded To General Dynamics For Construction Of Four Ships

The contract for the construction of the U.S.S. ARCHERFISH (SSN 678) and three sister ships to be delivered beginning with SSN 678 scheduled for 1 April 1972, and at four month intervals thereafter, was awarded to General Dynamics - Electric Boat Division on 25 June 1968. It was a fixed price incentive type contract and can be detailed on the following terms.

	TOTAL	PER SHIP
. Target Cost	$138,300,000	$34,575,000
. Target Profit	$ 15,700,000	$ 3,925,000
. Target Price	$154,000,000	$38,500,000
. Ceiling Price	$178,214,000	$44,553,500

The contract contained an incentive for early delivery which provided a "bonus" of $10 thousand for each calendar day in advance

of the current contract delivery date. This incentive was eventually paid on the SSN 678 in the maximum permitted amount of $1 million. Table E.37 outlines key events over the procurement.

TABLE E.37

SSN 678 MASTER SCHEDULE

Event	Date	Percent Complete
Start Construction	12/05/68	--
Keel	06/19/69	11.9
Engine Room Erected	12/16/69	24.3
Main Turbine Alignment	11/07/70	73.8
Launch	01/16/71	82.6
Preliminary Hot Ops Started	03/21/71	--
Final Hot Ops Started	06/03/71	94.6
Dock Trials Started	09/06/71	--
Acceptance Trials	12/07/71	--
Delivery	12/23/71	100.0

Note: Contractual delivery date had been extended from 1 April 1972 to 30 August 1972 due to allowable delays. Bonus therefore computed on August 1972 date.

During the construction period reprogramming shown in the August 1968 SCA Report made available additional "plan money" totalling $4.1 million and additional "basic construction money" amounting to $2.3 million. No further major changes to funding were surfaced which would be solely related to the hull-lengthening nor have any significant problem areas been found regarding these

plans and revisions. This is substantiated by the fact that all four submarines were delivered in advance of their respective contract delivery dates.

(5) Despite A 151 Day Extension Of The Contract Delivery Date (From 1 April 1972 To 30 August 1972), The SSN 678 Delivered In Advance Of The Original Date

The contractor requested via letters dated 31 December 1968 and 24 June 1969, that an extension of 151 days (from 1 April 1972 to 30 August 1972) be granted in order to allow for excusable delays. These included 63 days for delay resulting from a strike of the Metal Trades Union and 88 days due to non-receipt of Government Furnished Material. Despite the allowance of these excusable delays by the Government, the original delivery schedule was not jeopardized and, in fact, was bettered for all four ships built by General Dynamics - Electric Boat in this series, as seen in Table E.38.

TABLE E.38

FY 1967 SHIP DELIVERIES

Hull No.	Scheduled Delivery Date	Actual Delivery Date
678	04/01/72	12/23/71
679	08/01/72	05/05/72
681	12/01/72	09/01/72
684	05/31/74	04/05/73

The early delivery incentive appears, in this case, to have contributed the motivation to complete the construction of these ships ahead of schedule, thereby negating the probable cost growth which could have been reasonably anticipated due to the claimed magnitude of the delay. The progress evident in this instance, an average of just under 50 months for the four FY 1967 ships from award to delivery, is particularly noteworthy when compared to that exhibited for other ships of this class constructed in both private and public yards -- in some cases four extra years were required to effect delivery.

The following table shows the range of building period experienced by the SSN 637 Class.

TABLE E.39

BUILDING PERIODS

Months	No. of Ships*
Less than 50	8
50 - 62	13
63 - 74	8
75 - 86	5
87 - 98	2

* Less POGY

(6) ARCHERFISH Experienced Minimal Cost Growth After Contract Award

The ARCHERFISH shows a net cost growth of $14.3 million (to $84.3 million) over the originally authorized $70.0 million, including the $7.0 million incurred at contract award. However, tracking shows that before considering several costs which fell below budgeted amounts, thus negating some of the increase, cost growth in the plans and basic construction categories at delivery totalled $19.9 million. Of this, nearly $9.2 million was required for construction plan changes associated with the hull lengthening and other interior rearrangements. The increases by cost category are:

TABLE E.40

SSN 678 BUDGETED VERSUS ACTUAL END COST
(Dollars in Millions)

	Original Approved Estimate	End Cost At Delivery	Difference
Plans	-	9.2	9.2
Basic Construction	31.5	42.2	10.7
Change Orders	2.5	1.1	(1.4)
Electronics	7.4	6.8	(0.6)
HME	17.3	18.5	1.2
Post Delivery	1.4	-	(1.4)
NAVSEC	0.4	-	(0.4)
Ordnance	2.9	2.2	(0.7)
Escalation	2.4	4.3	1.9
Future Char. Changes	1.9	-	(1.9)
Other	2.3	-	(2.3)
Total	70.0	84.3	14.3

As previously mentioned, the SCA report of August 1968, indicates an additional $2.3 million was reprogrammed into the basic construction category and an additional $4.1 million was reprogrammed into the construction plans category. All or most of these increases were apparently related to hull lengthening. The increases in the plans and basic construction categories are summarized in Table E.41.

TABLE E.41

SSN 678 PLANS AND BASIC CONSTRUCTION COST INCREASES
(Dollars in Millions)

	Plans	Basic Construction	Related End Cost Estimate
Congress Baseline	-	31.5	70.0
March 1968 SCA	4.9	38.2	75.9
Delivery	9.2	42.2	84.3

While the record indicates that all plans costs were charged to the SSN 678, the overall increase from the originally quoted $0.7 million to about $18 million which included allowances for increased contractor labor, overhead and profit rates illustrates the significant impact upon estimate credibility and apparent cost growth brought about by changing characteristics/design subsequent to estimate preparation. The scope of the changes incorporated into the FY 67 ships is shown on the following page:

- Hull lengthening - 8' 3"
- Space and weight reservations for
  - Acoustic Information Gathering System (AIGS)
  - Improved PUFFS array and equipment
  - Satellite Navigation System
- Increased personnel accommodations
- Deep Submergance Rescue Vehicle capability
- Periscope charge
- Rearrange ECM space
- Update electronics suite
- Stowage for expendable bathythermographs
- Improved VHF/UHF/IFF Systems
- New Weapons Launch Console & Switchboard
- Revised noise goals

Additionally, from Table E.40, it can be seen that GFE costs were actually less than originally budgeted, even while supporting the update of various equipments. The decrease in GFE funding requirements aided somewhat in reducing cost growth in the plans and basic construction categories. Escalation growth in the case of the SSN 678 amounted to $1.9 million or only 13 percent of the total dollar growth.

In summary, while some of the cost growth can be attributed to changing market conditions or award delay and higher profit margins, the majority of the increased costs in basic construction, following analysis of available records, can be traced to significant changes which included hull lengthening, equipment updating and various interior rearrangements which could not have been considered by the estimator in late 1965.

3. THE SSN 678 EXPERIENCED A POST-AUTHORIZATION PROGRAM GROWTH OF APPROXIMATELY 20 PERCENT

- Growth totalled $14.3 million which included $1 million as a bonus for early delivery.
- Basic construction costs were increased by characteristic changes approved after budget submission and approval.
- Government estimated labor, overhead and profit rates were significantly lower than negotiated.
- GFE cost growth was negative
- No factors such as fast-paced material escalation, decline in productivity, availability of potential builders or shortages of skilled labor seemed to influence the construction process.

V. THE CASE STUDY OF THE FFG 7

This is the third ship program chosen by IMA for in-depth study. The FFG program met the requirements set down in the Interim Report for a case study of a surface combatant, lead ship, follow-on program of significant size and cost growth of such a magnitude as to warrant in-depth research. Additionally, the FFG program was a testing ground for several important and innovative acquisition-oriented management improvements in the Navy.

The vantage point from which the FFG program can now be studied is important. The evolution of the ship's requirement has been documented, design stages are substantially complete, the lead ship is about to be delivered and, therefore, many of the objectives of the program have been realized or missed. Further, the program's long production phase is starting and limited conclusions can be drawn concerning future plans and objectives in a more stable program environment. A detailed analysis of follow ships was not part of the contract requirements.

It is to be noted that the designation of the ship was changed from Patrol Frigate (PF) to Guided Missile Frigate (FFG) in September 1975. Therefore, in this study we will only use the designation FFG.

1. <u>THE FFG 7, FIRST SHIP OF A 74 SHIP PROGRAM, SHOWS SIGNIFICANT COST GROWTH WHICH MAY BE EXPLAINED BY ITS STATUS AS A LEAD SHIP</u>

The end cost of the FFG 7 is currently estimated to be $270,100,000 as of the current scheduled December 1977 delivery. Since the budget approved by Congress in 1973 for lead ship construction was $191,500,000, a cost growth of $78,600,000 has been experienced resulting in a percentage increase of 41 percent. This growth is comprised of increases in almost all categories of cost with significant growth in basic construction and GFM costs.

In addition to the rise in costs on the lead ship, total FFG program costs have risen significantly. The average unescalated unit cost per ship has increased approximately 55 percent since the approved development estimate. Escalation alone has increased over 1,100 percent. Program size has increased from 50 to 74 ships with construction continuing through FY 1988. The average escalated unit cost for each ship in the FFG program is now estimated at $187 million. Total program through 1988 now is predicted to be $13.8 billion, making it the largest combatant shipbuilding program -- both in number of ships and planned expenditures.

The following Table E.42 tracks the evolution of cost estimates from the early estimating thru the current estimates as of April 1977. The table also tracks the follow ship estimates (unescalated) thru April 1977. The details

TABLE E.42

EVOLUTION OF COST ESTIMATES
(Dollars In Millions)

	Initial Proposals Jan. 1971		Recommendations to CNO March to May 1971			Concept Exploration Report 7/71	Sept. 1971 NAVCOMPT Submission		OSD Submit 10/71	Congressional Submit Jan. 1972	Current Estimate April 1977
	ASW	AAW	ASW	AAW	Common Ship		Budget Prior to Reprogramming	Revised 1973 Submit			
Plans			87.0	55.0			72.3	69.3	69.3	63.2	56.8
Basic Construction			28.8	24.8			25.1	25.1	25.1	39.8	79.5**
Change Orders			2.0	2.5			2.0	2.0	3.0	2.0	16.2
Electronics			13.7	6.2			11.5	10.5	9.7	8.8	10.3
Propulsion Equipment										0.9	
H/M/E			8.2	8.2			16.2	14.1	14.1	6.8	43.2
NAVSEC (Other)			1.2	1.2			20.0	20.0	21.9	19.9	12.5
Escalation			10.5	7.7			9.9	9.9	9.9	6.2	
Ordnance			22.2	18.8			40.7	39.9	43.9	38.0	51.6
Electronic Growth			1.4	0.6			1.2	1.1			
Change Order Growth							1.0	1.0			
Ordnance Growth							4.1	4.0			
Project Managers Growth										5.9	
Total Cost of Lead Ship High:	146.6*	146.1*									
Low:	124.3	138.0	175.0	125.0		185.1*	204.0	196.9	196.9	191.5	270.1
Follow Ship Costs (Unescalated) High:	46.7	53.5	47.6	43.5							
Low:	33.8	46.8	45.6	40.6	47.7	49.2	47.8	45.0	44.4	45.0	126.9 (for follow ships through FY 1979)

* Unescalated

** This estimate is over $10 million higher than Bath Iron Work's estimate. The SCAs show this increase is mostly due to growth in the lead ship contract.

SOURCE: NAVSEA 01G Files; July 1971 Concept Exploration Report; Budget data.

of the estimates will be explained in subsequent sections of the report.

2. THE FFG PROGRAM RESPONDS TO A REQUIREMENT FOR COST EFFECTIVE ESCORTS TO REPLACE AGING WORLD WAR II DESTROYERS BEING PHASED OUT

In the late 1960's, several trends were apparent which led to decisions related to the creation of a new escort ship class. The trends were:

- The declining inventory of World War II destroyers -- the majority of which were over 20 years old and deficient in modern weaponry.
- An increasing requirement to upgrade the Anti-Air Warfare (AAW) and Anti-Submarine Warfare (ASW) capabilities for protection of sea lines of communication.
- The need for not only weapons-capable platforms but numbers of ships to "cover" the water, increase visibility and bring inventory levels up to more reasonable levels of risk.
- The need for a low-cost ship, large numbers of which could be financed in a period of increasing demand on available resources.

These trends and needs caused the CNO in January 1970 to order a Cost and Feasibility Study relative to the development of an escort type ship design. Approval for conceptual activities were included in PBD #507 (December 31, 1970) and on January 1, 1971 the FFG Conceptual Phase was begun.

Assumptions made at the outset were as follows:

- Ship design would take into account a $50 million limitation on cost.
- Two designs would be implemented -- one ASW and another, AAW -- with similar hull and operational characteristics.
- Total inventory would be about 50 ships.
- The ship would be "austere" with extensive use of off-the-shelf items and thoroughly tested weapons system.

The SHAPM organization concluded in March 1971 that a lead ship contract could be awarded in 1973. All plans were, therefore, oriented toward that goal.

3. A NUMBER OF MANAGEMENT TECHNIQUES WERE ADOPTED DURING EARLY PROJECT PHASES TO OPTIMIZE PERFORMANCE AND MINIMIZE COSTS

Plans to implement a program to meet the stated mission requirements were comprehensive and ambitious. The large number of ships planned implied a degree of cost control, intensive management and standardization that was not common in many other programs. Since various problems common in ship construction could be repeated in follow ships, a number of techniques were adopted to eliminate their causes to the maximum extent possible. The more important techniques implemented in the FFG program were as follows.

- Design-to-Cost
- Life Cycle Costing
- Lead Ship/Follow Shipbuilding Concept
- Land-Based Testing
- Central Procurement of Designated Standard Equipment Items
- Industry Participation in Design

(1) The Design-To-Cost Objective Has Been An Important Management Tool In The FFG Program

In a budgetary environment of decreasing real dollars, cost must be considered a controlling factor in the development of attainable operational and combat characteristics, inventory objectives, etc. Cost effectiveness in developing ships to be procured in large numbers is highly important, particularly when viewed with other requirements such as a nuclear carrier which can absorb almost a third of the available ship procurement funds. In a 74 ship program, therefore, cost per unit must be rigidly controlled to preclude cost overruns of major impact. The Design-to-Cost (DTC) techinque used in the FFG program is summarized as follows.

In the conceptual stages of the program, a design-to-cost goal is specified. This goal is necessarily established from very sketchy engineering data. Every precaution is taken to ensure that the goal does, in fact, reflect an affordable unit price from a budgetary point of view as well as serving as a viable goal which can

offer guidance to associated engineering activities. The development of the ship design, then, is a process of evaluating trade-offs in operating characteristics, weaponry and major equipment performance in order to produce the greatest capability for a given price at or within the established cost goal. The ship's characteristics having been initially established, the concept is firmed up and preliminary design work is completed. At this stage, the DTC dollar target is fixed. The DTC target, then, has the force of a management directive and can only be exceeded with the concurrence of top level management. The DTC target is effective until the follow ships are in the production phase and at which time a DTC dollar ceiling is specified.

The Design-to-Cost technique has its greatest impact during the design phase, with the lesser but important impact in engineering phases and relatively little impact during the production phase. From a management point of view DTC exerts a constant pressure to minimize costs and force cost consciousness throughout a program.

It should be noted that the fixing or freezing of the DTC goal at a point too early in development may well create more problems than problem solving. Unless the cost goal is a truly elastic figure, proper balance between cost and capability may not be forthcoming.

(2) The Application Of Design-To-Cost In Early Development Phases Was Related Closely To Life Cycle Cost Considerations

The overriding objective of DTC in the development phase is to minimize ship investment cost. Beyond this, however, decisions must be made which relate an initial investment to cost consequences throughout the ship's life.

The life cycle cost techniques adopted for the FFG program fall into the following areas:

- Acquisition cost - which involves reduced building and growth margins, tight configuration management, and reduced test requirements.
  - Weight margins were limited by CNO imposed restrictions.
  - The following Table E.43 compares the FFG margins to margins normally reserved on ships of similar type.

TABLE E. 43

WEIGHT MARGINS

	(%) Normal	(%) FFG
Preliminary and Ship System Design	3.0	1.5
Detail Design	4.0	4.0
Building Margin	1.0	1.0
Contract Mod. (during building)	1.25	1.0
Government Furnished Material	0.75	0.5
Total (percent light ship displacement)	10.0%	8.0%
K.G. Rise	.5 ft.	.25 ft.
Future Characteristics Changes	100 tons	None
Accommodations	10.0%	5.0%
Service Life (% of full load displacement)	5.00	75 tons

- Manning - reduction of normal personnel requirements.
  - Manning limit of 185 imposed (similar ship's manning normally 250) which anticipates a savings of $500 thousand per man over the ship's life.
  - Ship design predicated on efficient utilization of personnel, i.e., low maintenance, centralized office spaces, decreased watchkeeping requirements, etc.
- Availability and maintainability - extended overhaul cycle, on-board maintenance improvements.
- Fuel - Selection of low fuel rate systems.

(3) <u>A "Fly-Before-Buy" Concept Was Implemented In The FFG Program By Building A Lead Ship Before Procuring Follow Ships</u>

The FFG was a ship design that had potential for a number of production problems. A relatively complex sensor and weapons suite had to be installed in a smaller than normal platform. Additionally, to minimize production changes in line with the DTC target, potential engineering and producibility problems had to be identified and eliminated during lead ship construction. Finally, there were the problems associated with a relatively new propulsion system that was being modified for use on the FFG. For these and other reasons, the lead ship concept utilizing a cost plus incentive fee contract was selected in order to minimize the potential for future cost and

management problems.

The wisdom of this approach is borne out by the experience gained thus far in building FFG 7. A large investment was made to produce accurate engineering drawings during the construction period. Each engineering change was documented and it is expected that after lead ship construction is complete a set of Navy validated drawings will be available for follow ship construction. The validated drawing concept is designed to produce a high level of standardization, a firm engineering base, and feasible producibility in a number of potential shipyards. Builder risk is also reduced under this concept.

Certain problems (such as those encountered with the propulsion system) have occurred during lead ship construction which, if encountered simultaneously at different yards, could have caused significant delay and disruption, with an associated program cost increase. In retrospect, a period longer than the two years between lead ship completion and follow ship construction would have been preferable. As a result of lead ship construction delays, a larger than anticipated overlap has occurred with follow ships being built prior to the completion and testing of the lead ship.

(4) <u>Land-Based Testing Has Been Used Extensively As A Cost Saving Management Technique</u>

Land-based testing of the FFG combat and propulsion systems have produced mixed results. The purpose of the Land-Based Test Site (LBTS) was to alleviate integration and testing problems on lead and follow ships, and to accommodate early crew training. A combat system LBTS was established by Sperry Rand at Islip, L.I., N.Y. with sensors, fire control systems, gun and missile systems installed in an environment as close to shipboard conditions as possible. Integration of the combat systems -- normally a major source of production problems -- was accomplished at the test site. Crew training and installation efficiencies proved to be additional benefits derived from the LBTS concept. The major by-product of this concept has been a relatively problem-free installation and integration of the combat and command control systems on the lead ship.

In contrast, the LM 2500 propulsion system LBTS experience has been less successful. A partial propulsion system was installed at the Philadelphia test site -- main engines and direct support equipment -- but without control systems. While all problems related to the propulsion system were not identified nor corrected, there were, however, considerable benefits gained from land-based

testing, such as training, endurance testing, etc.

(5) <u>A System Of Central Procurement For A Selected Number Of Standard Equipment Items Was Established</u>

Pursuant to standardization objectives, the contract originally specified some 60 equipment items (valves, pumps, generators, etc.) as standard, for which options for purchase were to be arranged by the lead ship contractor. As originally specified, BIW was to receive a bonus for favorable prices as measured by a predetermined scale of prices, the practice, however, was discontinued by mutual consent as being too complicated. This general concept has been successful and provides an assurance of standardization benefits for follow ships. The list of 60 items has been reduced to 43 in accord with market conditions. These include items such as pumps, propulsion control systems, generators, etc. As an adjunct to this central procurement concept BIW administers the warranty on these stock items for up to six months subsequent to delivery to follow ship builders.

(6) <u>Normal Acquisition Phasing Was Modified To Allow Early Participation By Potential Builders</u>

An initial goal in the FFG program was to produce a ship design which represented not only the best the Navy could develop, but one which also reflected the ideas of shipbuilders and engineering

firms which might eventually participate in production phases. It was reasoned that such collaboration in ship design would produce better quality design, increased producibility, attract more enlightened bids and thus ensure broader industry participation in follow ship production. Additionally this technique of early shipbuilder participation was designed to encourage, during detail design:

- More realistic estimates for basic construction by the designated lead shipbuilder.
- An added positive factor of having the secondary design agent (follow shipbuilder) as an alternate lead shipbuilder.
- Added incentive for the lead shipbuilder to negotiate realistically.

To this end, a potential lead ship builder (Bath Iron Works assisted by Gibbs and Cox) was selected to work with NAVSEC to devise a lead ship design baseline with appropriate drawings. Further, a potential follow ship builder (Todd Shipbuilding) was put under contract to devise ways of assuring producibility in a variety of yards.

Having summarized the techniques to be used in ship development, program milestones were projected as follows:

. Release RFP for SSD	11/71
. NAVSEC start SSD	11/71
. Shipbuilder start SSD	02/72
. Start LLT GFE buys	06/72
. Start Detail Design	06/72
. Delivery lead ship	12/76
. Delivery first follow ship	04/78
. Delivery last follow ship	04/82

This schedule assumed that the lead ship could be constructed in 32 months, follow ships in 24 months, and further that three yards would

each build four ships per year with a resultant overall delivery rate of one ship per month.

An equally important activity during the pre-implementation period was the preparation of early FFG estimates which lead to the budget estimates submitted during the last quarter of 1971.

4. EARLY FFG ESTIMATING WAS INITIATED BY A CNO REQUEST FOR COST AND FEASIBILITY STUDIES

The significant chronological events involving the development and submission of these estimates commencing with the early requests for small escort design and configuration options through the approved estimates are as follows:

TABLE E.44

SUMMARY OF EARLY ESTIMATE EVENTS

DATE	EVENT
January 1970	Begin review of escort design and configuration options
September 1970	CNO Request for Cost and Feasibility Study for new patrol escort ship
December 1970	Results of initial feasibility and cost studies issued; costs to be limited to $50 million per ship.
January 1971	Presentation to CNO of various alternatives confirming general feasibility of Patrol Escort in the $40-50 M range, (for follow ships).

TABLE E.44
(continued)

DATE	EVENT
March 1971	Concept Design phase approved for Patrol Frigate (FFG)
March/April 1971	Propulsion System studies completed with a decision for a gas turbine system. Trade-offs between additional cruise engines, and single vs. twin shaft.
	Studies conducted concurrently on the initial ASW/AAW weapon candidates. SHAPM report indicating feasibility of lead ship award in FY 1973.
April/May 1971	CNO and CNO Executive Board presented the results of cost, effectiveness, and feasibility studies.
May 1971	CNO selected characteristics for basic ship. The follow ship cost increased from the January 12 cost of \$33.8M to the April 29 cost of \$45.6M, including the decision to have a single shaft propulsion system. (See Table E.46.)
Late May 1971	CNO modified FFG Characteristics for LAMPS, Sonar, Oto-Melara Gun. (See Table E.45.)
June 1971	Preliminary design commenced. Concept Exploration report issued with lead and follow ship "F" estimates of \$185.1 million and \$49.2 million, respectively. Decision made to have single ship platform vice one AAW and one ASW ship platform.
August 1971	Conceptual design estimate for the lead ship revised to "D" estimate.
September 1971	Lead ship estimate forwarded to NAVCOMPT as class "D" at \$204 million subsequently reduced by NAVCOMPT to \$196.9 million.

TABLE E. 44
(continued)

DATE	EVENT
October 1971	OSD submission from NAVCOMPT of $196.9 million for lead ship
January 1972	OSD revised submission and approved Congressional budget estimate of $191.5 million for lead ship.

The following Table E.45 is a summary of the evolution of major characteristics changes for the lead ship. The information following the Table presents the details in the evolution of characteristics.

(1) The Guided Missile Frigate (FFG) Trade-Off Studies Conducted In Early 1971 Included Several Hundred Alternate Ship Configurations

The trade-off studies utilized a standard basic ASW and AAW ship platform and conducted trade-off studies for various propulsion and weapon and electronic suites. With the various suite alternatives the lead ship cost estimates ranged from $121 million to $147 million. The estimates for follow ships ranged from $34 to $47 million per ship.

The AAW trade-offs included suite variations with cost estimates for lead ship between $138 and $146 million, and follow ship estimates between $47 and $54 million.

TABLE E.45

EVOLUTION OF MAJOR CHARACTERISTICS

	January 1971 Initial Presentation to CNO		April 1971 Recommended Alternatives						CNO Selected Characteristics May 1971 Common Ship(4)	Preliminary Design Submit October 1971	Congressional Budget Submit January 1972	Present Characteristics November 1976
	ASW	AAW	ASW Basic	ASW Basic w/SQQ-23 vice SQS-505	AAW Basic	AAW 1	AAW 2	Common Ship				
Propulsion	Twin Screw w/2 LM 2500s, 2 TYNEs or Twin Screw w/ 2 LM 2500s, 2 Diesels; or Single Screw w/ 2 LM 2500s, 5 TYNE	Twin Screw w/ 2 LM 2500s, 2 TYNE; or Single Screw w/ 2 LM 2500s, 1 TYNE	Single Screw COGAG (3)	Single Screw COGAG	Single Screw COGAG	Single Screw COGAG	Single Screw COGAG	Single Screw COGAG	Single Screw w/ 2 LM 2500s, 1 TYNE (with cruise and take home)	Single Screw w/ LM 2500s, 1 TYNE (with cruise and take home)	Single Screw w/ LM 2500s, 1 TYNE (with cruise and take home)	Single Screw w/ LM 2500s, 1 TYNE (with cruise and take home)
Launchers	MK-16 ASROC/ HARPOON, or MK-26	MK-26	SEASPARROW	SEASPARROW	MK-22	MK-15 Mod 1	MK-22 MK-16	MK-26 Mod 0	MK-13 Mod 1	MK-15 Mod 1	MK-12 Mod 1	MK-15 Mod 1
	2 MK-32 TT	2 MK-32 ST	2 MK-32 TT	2 MK-22 TT	2 MK-32 TT	2 MK-32 TT	2 MK-32 TT	2 MK-32 TT	2 MK-22 TT	2 MK-32 TT	2 MK-32 TT	2 MK-32 TT
Gun/Missile FCS	MK-87	MK-74 or 2 Channel TARTAR D	MK-87 CWI/ STIR	MK-87 CWI/ STIR	MK-87 CWI/ STIR	MK-87 CWI/ STIR	MK-87 CWI/ STIR	MK-87 CWI/ STIR	MK-87 CWI/ STIR or MK-74 Fallback	MK-74 (TARTAR C) or MK-92 (MK-87 with CWI)	MK-92 (with CWI and SPG-60 STIR)	MK-92 (with CWI and SPG-60 STIR)
UFCS			MK-114	MK-144			MK-114	MK-114	MK-309 Control Panel	MK-309 Control Panel	MK-309 Control Panel	MK-309 Control Panel
Weapons	LAMPS HARPOON SEA SPARROW Oto-Melara Gun or 5"/54 Gun	HARPOON Standard Missiles 2 CIWS	35 mm Gun ASROC AIM 7F HARPOON LAMPS	35 mm Gun ASROC AIM 7F HARPOON LAMPS	35 mm Gun SM-1 Missile HARPOON	35 mm Gun SM-1 Missile HARPOON	SM-1 Missile HARPOON ASROC	35 mm Gun SM-1 Missile HARPOON ASROC	LAMPS; HARPOON and Standard Missiles; 35mm Oto-Melara Gun or 76 mm Fallback MK-44 Torpedo	LAMPS HARPOON 35mm Oto-Melara Gun 76mm Oto-Melara Gun	LAMPS(1) CIWS (Sp. & Wt.) HARPOON 35mm Oto-Melara Gun	LAMPS LAMPS III (Sp. & Wt.) HARPOON, CIWS (Sp. & Wt.) 76mm Oto-Melara Gun MK-48 Torpedo
Radars Air-Surface	SPS-58 SPS-10	SPS-52 SPS-10	SPS-49 SPS-55	SPS-49 SPS-55	SPS-49 SPS-55	SPS-49 SPS-55	SPS-49 SPS-55	SPS-49 SPS-55	AN/SPS-49 AN/SPS-55	AN/SPS-49 AN/SPS-55	AN/SPS-49 AN/SPS-55	AN/SPS-49 AN/SPS-55
Sonar	ED 0610E SQS-26 TACTLASS (and Prairie Masker)	ED 0610E	SQS-505 TACTLASS	SQS-505 (pair) TACTLASS	SQS-505	SQS-505	SQS-505	SQS-505 TACTLASS	AN/SQQ-23 (pair) TACTLASS (Sp. & Wt.)	AN/SQQ-23 (pair) SQS-505 TACTLASS (Sp. & Wt.)	AN/SQQ-23(1) TACTLASS (Sp. & Wt.)	AN/SQS-56(2)
Countermeasures	Passive EW	Passive EW	WLR-8 or WJ-1007	WLR-8 or WJ-1007	WLR-8 or WJ-1007	WLR-8 or WJ-1007	WLR-8 or WJ-1007	WLR-8 or WJ-1007	WLR-8 or WJ-1007	WLR-8 or WJ-1007	WLR-8	WLR-8

(1) CNO modified PF characteristics in May 1972 to reflect:
- 2 LAMPS Helicopters
- 76 mm Oto-Melara Gun
- SQS-505 Sonar

(2) The SQS-505 Sonar was dropped in June 1973 and replaced with the SQS-56.

(3) COGAG Includes:
- 2 LM 2500s
- Four 75 KW s/s Diesel Generators
- 2 Distilling Plants
- 2 Auxiliary Boilers

(4) Used in the Conceptual Report dated July 1971.

SOURCE: NAVSEA 01G files and July 1971 Concept Exploration Report budget information.

TABLE E.46

EVOLUTION OF COST ESTIMATES
($ IN MILLIONS)

	Initial Proposals 1/71 ASW	Initial Proposals 1/71 AAW	Recommendations to CNO 5/71 ASW	Recommendations to CNO 5/71 AAW	Recommendations to CNO 5/71 Common Ship	Concept Exploration Report 7/71	9/71 NAVCOMPT Budget prior to Reprogramming	9/71 Submission Revised '73 Submit	OSD Submit 10/71	Congressional Submit 1/72	Current Estimate 4/77
Plans			87.0	55.0			72.3	69.3	69.3	63.2	56.8
Basic Construction			28.8	24.8			25.1	25.1	25.1	39.8	79.5
Change Orders			2.0	2.5			2.0	2.0	3.0	2.0	16.2
Electronics			13.7	6.2			11.5	10.5	9.7	8.8	10.3
H/M/E			8.2	8.2			16.2	14.1	14.1	7.7	43.2
NAVSEC			1.2	1.2			20.0	20.0	21.9	19.9	12.5
Escalation			10.5	7.7			9.9	9.9	9.9	6.2	
Ordnance			22.2	18.8			40.7	39.9	43.9	38.0	51.6
Electronic Growth			1.4	.6			1.2	1.1			
Change Order Growth							1.0	1.0		5.9	
Ordnance Growth							4.1	4.0			
Total Cost of Lead Ship High:	146.6	146.1									
Low:	124.3	138.0	175.0	125.0			204.0	196.9	196.9	191.5	270.1
Follow Ship Costs (Average) High:	46.7	53.5	47.6[1]	43.5[1]		185.1					
Low:	33.8	46.8	45.6	40.6	47.7	49.2	51.0	48.2	47.5	47.2	147.7 (for follow ships through FY 76)
			46.0[2]	48.5[2]							

1) Concept Exploration Report
2) NAVSEA 01G Files
3) Target Cost

(2) Studies On The Various Sonars, Radars, Propulsion Systems, And Weapon Suites Were Completed

As cost data and ship feasibility studies progressed, it became apparent that the weapon suite would be a major decision -- having the largest impact on ship's size and cost. The weapon combinations tested were based on various threats and ship missions.

The final weapon suite analysis narrowed to three ASW and two AAW suites for the ASW version of the FFG and to three ASW and four AAW suites for the AAW version of the FFG.

(3) In May 1971, The CNO Approved A Single Ship Platform For The Escort (FFG) Program

While conducting the cost and feasibility studies, it became apparent that a "single" ship to perform both missions was possible. In April the ship characteristics for alternative ASW and AAW ships, as well as that for a common ASW/AAW ship, were presented for approval. These final recommendations were a result of hundreds of computer feasibility studies. As a result of this briefing and others which followed, the CNO selected the ship characteristics in May 1971, based on a common ASW/AAW ship (see Table E.45). The official mission statement from OPNAV was issued at a later date.

5. THE CONCEPT EXPLORATION REPORT OF JULY 1971 ESTABLISHED TARGETS FOR LEAD AND FOLLOW SHIP COSTS AT $185.1 MILLION AND $49.2 MILLION, RESPECTIVELY

Target costs were established based on an FFG "single ship platform," thus eliminating the ASW/AAW separate ship concept. The estimates were Class "F" based on a 50 ship acquisition program with lead ship award planned for 1973.

The FFG Concept Exploration Report documented major decisions made during the six month Conceptual Phase. It highlighted program objectives of minimizing size and cost of the ship consistent with mission requirements, estimating resource requirements accurately and production of the ship at or below published targets. Further in the way of objectives, the Guided Missile Frigate's mission was stated as "effectively supplementing existing and planned ASW and AAW escorts in protection of amphibious forces, underway replenishment groups, and military or mercantile convoys against air, surface or subsurface threats."

6. DURING THE PRELIMINARY DESIGN PHASE, BUDGET ESTIMATES OF $191.5 MILLION AND $47.2 MILLION FOR LEAD AND FOLLOW SHIPS RESPECTIVELY WERE SUBMITTED TO CONGRESS

During June of 1971 technical engineering activities were begun by NAVSEC. Payload characteristics and operational specifications had been promulgated by CNO in early May which paved the way for the preliminary

design phase. The objective during preliminary design was to produce a Functional Baseline (FBL) for the ship which could be utilized by the Navy and shipbuilding firms in the further development of ship system design. An RFP for ship system design activities was prepared for this purpose and release to the industry was planned to coincide with completion of the FBL. During this preliminary phase (July 1971 to December 1971), budget figures were submitted for the FY 1973 program year.

(1) Pressure Began In August 1971 To Develop A Class "D" Estimate For The Lead And Follow Ships To Coincide With Expected Completion Of Preliminary Design In September 1971

NAVSEA 01G1 was requested to provide the FFG SHAPM with a list of information needed to update the FFG estimate to class "D." The following information was requested.

- Details on ship systems engineering
- Details on contractor test and evaluation
- Method of procurement, scheduling details
- Propulsion plant test site and command/control estimates
- Requirements for combat system integration and configuration training

(2) The Class "D" Budget Estimate Sent To NAVCOMPT In September 1971 Estimated Lead Ship Cost To Be $204 Million

The NAVSEA estimate of $204 million for lead ship construction was immediately adjusted downward by $7.1 million after initial

NAVCOMPT review and a revised budget estimate of $196.9 million was resubmitted by NAVSEA. The reduction was accompanied by a reprogramming of FY 1972 funds involving the MK 92 FCS, Oto-Melara 35 mm Gun, MK 13 Launcher, SQQ 23 Sonar and the H/M/E hot plant, so that design and development activities could commence at any early date.

(3) The Budget Estimate Submitted To OSD Was Subsequently Reduced To $191.5 Million

The budget estimate for the FFG lead ship as submitted by NAVCOMPT to OSD was, in three separate Program Budget Decisions (PBDs), reduced from $196.9 million to $191.5 million. The net $5.4 million reduction was effected in the following areas.

TABLE E.47

EFFECT OF FFG LEAD SHIP PBDs

Item	Amount ($ in millions)	Reason
FFG Advance Design	-10.0	Reprogramming of FY 72 RDT&E funds
Universal Hot Plant (PSLBTS)	+ 8.3	Disallowed OPNAV funding in FY 73; changed to SCN funding
Escalation	- 3.7	Navy required to utilize OSD approved BLS projections for the previous year instead of NAVCOMPT's projections
Net	- 5.4	

Therefore, as a result of these decisions, the lead ship was estimated at $191.5 million and the average price of a follow ship (originally scheduled for award in FY 1975) was $47.2 million. The $191.5 million lead ship estimate included the construction of the lead ship, detail design and lead ship central procurement activities.

The key components of the estimate submitted to the Congress were as follows:

- Major categories

- Plans	$63.2 million
- Basic Construction	39.8
- Ordnance	38.0
- Escalation	6.2
- Change Orders	2.0
- Electronics	8.8
- Propulsion	.910
- H/M/E	6.79
- Other	19.9
- PM Growth	5.9

- Plans at $63.2 million were uncommonly high because design and engineering during construction of the lead ship was to be intensive. Changes were apt to be higher than normal and activities related to validated drawings would continue until contract trials were complete.

- Basic Construction was estimated as $39,800,000 and was comprised of:

- Labor man-hours	1,568,247
- Labor dollars	$ 6,747,384
- Overhead dollars	$ 4,858,116
- Material dollars	$22,629,331
- Profit and weight margins	$ 5,608,963

The original NAVSEA 01G estimates for basic construction rose from $25.1 to $39.8 million when the propulsion system was designated CFE vice GFE and costs were transferred from H/M/E (GFE) into basic construction. The propulsion equipment for the land-based test site was also included in the higher basic construction estimate. The addition to material costs for the LM 2500 and other items such as reduction gears, CRP propeller, and start-up costs totalled $14.7 million.

- The ordnance estimate of $38.0 million included the following:

		Number	Est. Cost (000's of Dollars)
-	MK 13 GMLS	1	5,350
-	MK 32 Torpedo Tubes	2	85
-	MK 92 (w/CWI and SPG-60 STIR)	1	11,550
-	MK 309 Control Panel	1	100
-	LAMPS (one 5H-2D Helo)	-	-
-	HARPOON Dedicated Controls	-	100
-	35 mm Oto Melara Gun	1	9,530

- Also included in the Congressional submission were estimates for electronics as follows:

		Number of Units	Estimated Cost (000's of Dollars)
-	AN/SPS 49	1	825
-	AN/SPS 55	1	86
-	SQQ 23 (PAIR)	1	2,477
-	WLR 8	1	550
-	TACTLASS (space/weight)	1	-
-	NIXIE	1	200

- Escalation in the Congressional submission was reduced significantly from \$9.9 to \$6.2 million, a drop of \$3.7 million. The escalation percentage of the lead ship end cost was budgeted at 3.2 percent as compared with the original feasibility studies which utilized a five percent rate.

The Functional Baseline for the ship was completed at the beginning of December 1971 and the RFP released, thus ending the preliminary design phase.

(4) <u>The Follow Ship Cost Estimate Associated With The Congressional Submission For The FY 73 Lead Ship Was \$47.2 Million</u>

The follow ships were to be included in the FY 1975 budget, at which time it was planned that follow ship estimates would be budget quality and based on lead ship experience, maturity and validation of design, as well as shipbuilder participation in design and planning. The main unknowns in the follow ship estimates concerned potential changes in the combat systems, i.e., the development of LAMPS I to LAMPS III; MK 92/D FCS and Oto Melara "Americanization;" and HARPOON development/integration.

- The labor man-hours for basic construction in the follow ship estimate was 1,159,278. This figure was almost 409,000 man-hours less than the lead ship estimate. Additionally, the material estimates on the follow ships were almost \$14 million less than the lead ship. A large portion of this difference is attributed to the additional propulsion costs added to

the lead ship as CFE. Total basic construction estimate for the follow ships was $26.7 million.

- The ordnance estimate for follow ships was $8.6 million.

- Escalation projections are based on a factor of 4.7 percent of the ship's target price which is somewhat less than in early feasibility estimates.

- The profit percentage remained at 10 percent on the follow ship estimates vice 12 percent on lead ship.

It is interesting to note that the FY 1975 follow ship costs estimates as of April, 1977 have risen to $134.5 million. Of this amount, $25.2 million is for ordnance, and $54.9 million is attributed to increases in basic construction. Escalation budgeted is $18.5 million; which amounts to 13.8 percent of total ship estimate.

7. THE PRE-PRODUCTION AND DESIGN PHASE BEGAN EARLY IN 1972 AFTER BUDGET SUBMISSION AND HAS PROGRESSED TO THE POINT OF 90 PERCENT COMPLETION ON LEAD SHIP CONSTRUCTION

Common practice in the Navy calls for contract design to be developed by NAVSEC, with the final product being an Allocated Baseline on which contractors can bid for award of a construction contract. In the case of the FFG, an attempt was made to produce a ship design which represented not only the best the Navy could develop, but which also reflected ideas of shipbuilders and engineering firms that would eventually participate in production phases.

An RFP for Ship System Design (SSD) participation was sent to a number of shipbuilders. While responses were being prepared NAVSEC began activities directed toward preparation of an Allocated Baseline. Four shipyards submitted bids, with the Bath Iron Works and Todd Shipyards bids being accepted. Two shipyards submitted bids which, in the opinion of the Navy, were too high. Bath Iron Works was awarded a CPFF (Cost Plus Fixed Fee) contract for $3.15 million as the primary design agent and potential lead shipbuilder. Todd Shipyard was awarded a contract to review the lead ship baseline for $1.78 million and was considered to be a potential follow shipbuilder.

The following outlines the growth which took place in the SSD contract:

TABLE E.48

CONTRACTOR COSTS
(millions of dollars)

	Initial Contract Price	Current Price		Price of Completion		Comments	Date of SAF
		Target	Ceiling	Cont. Est.	Govt. Est.		
S ip System Design Support Bath Iron Works - 4/12/72	3.15	14.8	N/A	14.8	14.8	Modifications to increase scope are planned	03/73
	3.15	26.8	N/A	26.8	26.8	$12.0 million increase for planned procurement of gas turbines, propulsion system LBTS, initial detail design under this contract	06/73
	3.15	3.6	N/A	3.6	3.6	Modifies 5/1/73 to start detail design until combined CPFF/CPIF contract for detail design and contraction signed 10/73	12/73

Three different organizations then, were participating in the Ship System Design as of April 1972: NAVSEC, Bath Iron Works (supported by Gibbs and Cox) and Todd.

During the Ship System Design Phase, preliminary plans were made for major ship systems testing which included Combat System and Propulsion System Land-Based Test Sites.

In addition to the test site plans, other necessary planning documents were issued:

- Test and Evaluation Plan (February 1972)
- Operational Manning Plan (June 1972)
- Combat System Management Plan (June 1972)
- Computer Software Management Plan (August 1972)
- ILS and Training Plans (October 1972)

The information published in these documents, along with the progress on the Ship System Design, allowed the Top Level Specification (TLS) to be promulgated in October 1972 with new characteristics approved by CNO during the same month.

These actions completed preparations for a DSARC review scheduled for August 1972.

8. A SUCCESSFUL DSARC I AND II REVIEW HELD IN AUGUST 1972 SET THE STAGE FOR THE SIGNING OF A DETAIL DESIGN AND LEAD SHIP CONSTRUCTION CONTRACT

In normal acquisition procedure, DSARC I is held to review program concept and approve proceeding with preliminary design; DSARC II determines whether to proceed with full scale development and specifically, contract design. In the case of the FFG program, DSARC I and II were combined. An independent cost estimate was prepared by OP 96 for the combined DSARC meeting scheduled for August 1972 and determined that cost projections for the lead ship and follow flights were reasonable and within acceptable risk. Program plans were approved and acting on the DSARC recommendations, DEPSECDEF (in September 1972) authorized a 56 ship program, lead ship construction and land-based test site development. Immediate negotiations were begun with Bath Iron Works for detail design and construction of the lead ship.

In December, the Preliminary Allocated Baseline (PABL) was completed. The PABL, prepared largely by NAVSEC with Bath Iron Works' participation, was sent to Todd for a thorough review. In February, Todd submitted some 230 improvement recommendations. These recommendations, where appropriate, were incorporated into the Preliminary Lead Ship Allocated Baseline (LSABL) and in April, the specifications and contract drawings for construction of the lead ship were signed.

The RFP for lead ship construction was released in May 1973. In June, Bath Iron Works submitted its bid. Negotiations continued until October when a contract was signed and included the following two tasks:

- Detail design and activities leading up to Validated Follow Ship Drawings, lead ship planning, special studies and procurement of propulsion system for lead ship and LBTS; task awarded for $42,914,000 under Cost Plus Fixed Fee.

- Construction of the lead ship and central procurement of certain standard items for the lead ship; awarded for $49,500,000 under Cost Plus Incentive Fee.

Table E.49 summarizes the contract price growth since October 1973. As is seen, the majority of growth is due to engineering changes and change orders.

TABLE E.49

CONTRACTOR COSTS
(millions of dollars)

	Initial Contract Price	Current Price Target	Current Price Ceiling	Price at Completion Cont. Est.	Price at Completion Govt. Est.	Comments	Date of SA
Detail Design and Lead Ship Construction	92.5	92.5	N/A	92.5	92.5		12/73
Bath Iron Works - 10/73	92.5	98.1	N/A	98.1	98.1	Change orders including the addition of a fourth 1000 KW ship's service diesel generator	06/74
	92.5	97.9 (1)	N/A	111.0 (2)	109.5 (3)	(1) reduced cost changes during detail design; (2) contractor furnished material cost increases; (3) lower Navy material estimates based on contractor commitment to date	12/74
	92.5	99.3	N/A	112.4	119.9	Engineering changes during detail design develop.	06/75
	92.5	106.3	N/A	121.4	130.1	Engineering changes during detail design, additional work task assignments, drawing validations	12/75
	92.5	103.4	N/A	119.1	129.3	Engineering changes during detail design	03/76
	92.5	113.6	N/A	130.5	130.5	Engineering changes and six month delay in contract delivery date	09/76
	92.5	122.5	N/A	133.5	133.5	Engineering changes, projected cost growth	12[illegible]
	92.5	122.9	N/A	137.9	137.9	Engineering changes and cost growth	03/77

Detail design began at Bath subsequent to completion of the Ship System Design phase which provided a Lead Ship Allocated Baseline. The objective was to proceed from the Lead Ship Allocated Baseline and associated specifications and drawings to arrive at a guide to build the lead and follow ships. To assure that the drawings would, in fact, represent the as-designed/as-built conditions, great pains were taken to update drawings at each change and prior to performance of any shop or yard work. All work on the lead ship was to be from as-built drawings thus providing a high degree of assurance that the validated drawing concept would operate successfully by eliminating most of the usual drawing "bugs."

9. THE DETAIL DESIGN AND CONSTRUCTION PERIOD FOR THE LEAD SHIP CAN BE CHARACTERIZED BY NUMEROUS ENGINEERING CHANGES, CHANGE ORDERS, AND DESIGN CHANGES

Problems surfaced early in the program and resulted in a six month slippage of the lead ship delivery date and subsequantly contributed in part to increase in the detail design contract. The March 1977 Estimate at Completion for the FFG 7 was revised upward to $63.8 million, a $21 million increase.

Various reasons are given for this cost increase:

- The design subcontractor, Gibbs and Cox, contract cost increased by over $10 million because of the following:

- Defective specifications and information from NAVSEC resulted in inaccurate information being sent to vendors.

- Additional manpower and hours were required to make up schedule slippage on vendor procurement.

- Delays in drawings occurred due to the factors above as well as required engineering changes.

. The validated drawings concept has proved beneficial but additional time was required for implementation.

  - Extra time and delays were expended in the approval and documentation of changes.

  - Extra time was required to prepare and incorporate revision notices into design drawings.

. A large number of paper changes surfaced during lead ship construction.

. Slippage in CFE purchase order schedules.

Some of these early design changes included modifications to the firefighting system, fresh water piping, ballasting system, etc. Other changes such as the following were also incorporated into the design:

. Revision of lead ship specifications for compliance with revised rules of the road - 1972

. Modify design due to change in GFE (AN/WSC-3 SATCOM Transceiver)

. Change in intermediate GFI for HARPOON

. CRP instrumentation

. Revised validation requirements

- Special studies

- LM 2500 documentation

- Modifications due to change in intermediate GFI for SQS-56 sonars and AN/SPS 49 radars

During lead ship construction many cost drivers were identified:

- Labor overruns caused by labor hour increases in ships assembly and integration engineering (complex ship/small hull)

- Increased material costs driven by increased reliability assurance requirements giving rise to the view that the ship is "gold-plated" and not austere because of reliability requirements.

- Propulsion system at the LBTS required numerous engineering changes with attendant cost increases and delays.

- Late GFM at the Combat System Land-Based Test Site and increased GFM testing have been factors of delay and cost increases in the construction of the FFG 7, mainly in the case of the AN/SPS 49 Radar, SQS 56 Sonar, and MK 92 FCS.

As previously mentioned, a number of cost significant engineering changes were made during lead ship construction. The original estimates (at OPNAV's direction) made no provisions for future characteristics changes. Consistent with design-to-cost criteria, growth margins were held at minimum levels. However, after the start of lead ship construction several changes were identified and determined as essential. These changes included the following:

- A fourth diesel generator
- A fifth fire pump
- Additional computer memory modules
- Additional longitudinal bulkheads below the second deck to damper vibration
- Space and weight provisions for fin stabilizers

None of these items could have been included in the NAVSEA 01G estimates unless design-to-cost criteria had been updated earlier.

Other major modifications during the construction phase can be attributed largely to the fact that the FFG 7 was a lead ship of a very large class and thus in some respects considered a prototype. A listing of significant modifications follows:

- Ships firefighting capability had to be redesigned
- MK 13 GMLS control room had to be rearranged
- Missile fire control systems were modified
- Lead ship design revisions to reflect fresh water piping, drainage, and ballasting system changes
- Rearrangement of the combat information center to conform to that developed by Gibbs and Cox for the follow ships
- Modify full scale pilot house mock-up - Ship control control relocation - pilot house rearrangement
- Modify helicopter handling, servicing and storage facilities

- Propeller shaft changes
- Deletion of torsion meter
- Installation of MK 27 gyro compass

The net result of these changes has been a delivery delay of at least nine months, with an associated estimated increase in cost of construction and design of approximately $39 million.

The following table reflects the contract modifications negotiated related to the detail design activities and construction of the lead ship:

TABLE E.50

HMR'S/FMR'S
SUMMARY

Total Modifications (According to Dollar Value)

Indiviudal Mods	Number of Mods	CPFF	CPIF	Total
>1M	6	$10,914,856	$ 4,922,747	$15,837,603
>500K	7	1,101,213	2,293,418	3,394,631
>100K	23	2,725,968	1,367,575	4,093,543
	36	$14,742,037	$ 8,583,740	$23,325,777
<100K	327*	11,154,810	2,229,524	13,384,334
Total Changes Recorded		$25,896,847	$10,813,264	$36,710,111
Increases in Contract Price Estimate at Completion		$20.9M	$18.3M	$39.2M

* Of the 327 other contract modifications (as of April 1977), only 109 involved changes in dollar amounts according to SupShip Bath.

SOURCE: SupShips Bath

10. AN ANALYSIS OF DETAIL DESIGN AND BASIC CONSTRUCTION ESTIMATES VERSUS ACTUAL COSTS NEAR COMPLETION OF THE LEAD SHIP SHOWS SIGNIFICANT DIFFERENCES

The (April 1977) estimated contract price at completion for FFG 7 is approximately $67.8 million. Compared to the approved budget estimate, $39.8 million, for basic construction (based on updated NAVSEA 01G estimates) dated January 1972, estimate at completion (EAC) for basic construction (contract price) shows a 70 percent cost growth.

A more detailed analysis of these increases in basic construction since the approved Congressional budget estimate shows the following:

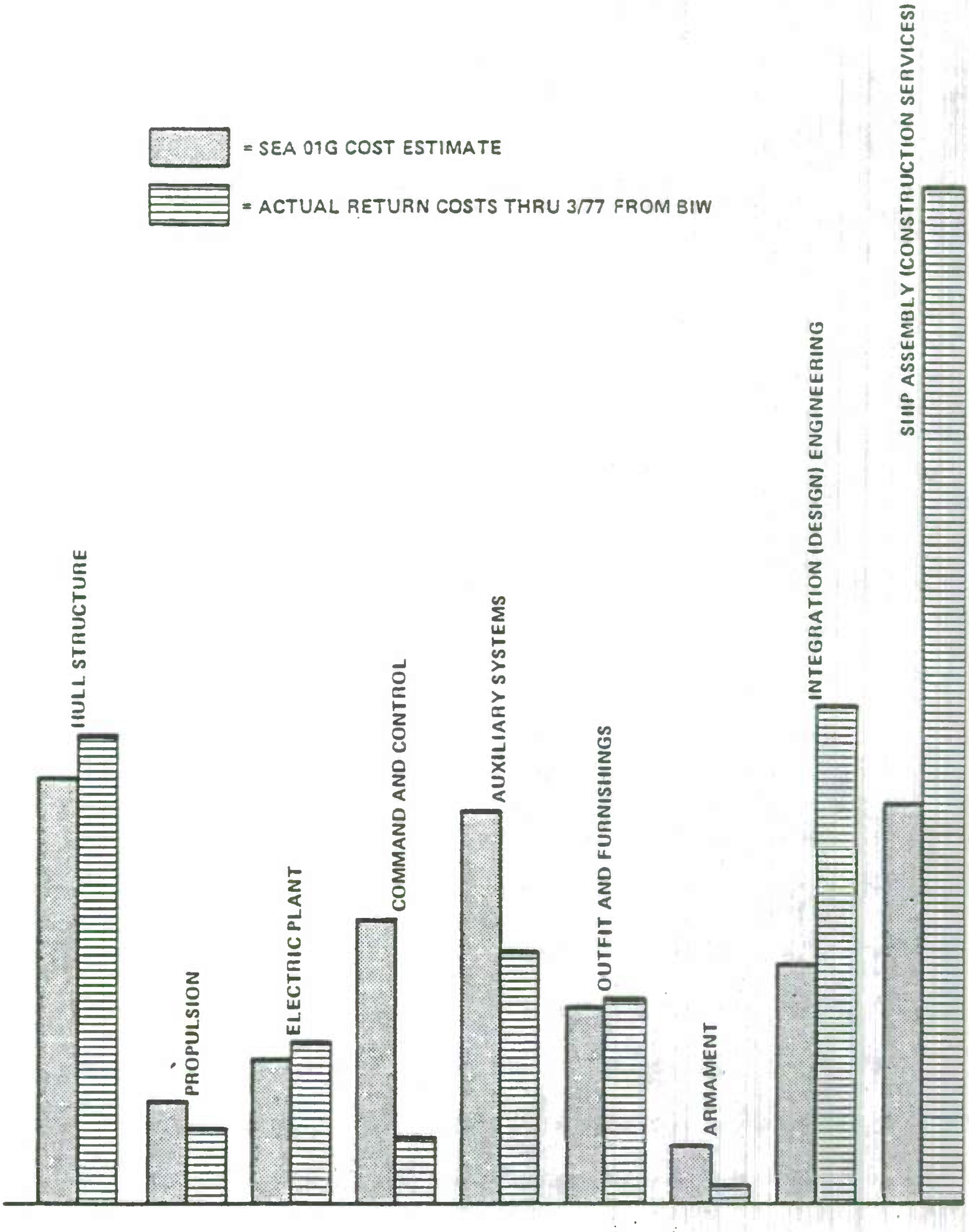
- The estimated labor-hours for basic construction were exceeded by April 1977 when the lead ship was approximately 77 percent complete.

  The original estimate by SEA 01G, approximately 1.56 million labor hours, is expected to be exceeded at ship completion by over 1.4 million labor-hours, a 91 percent labor-hour growth.

- The two major basic construction areas underestimated were Integration (Design) Engineering and Ship Assembly (Construction Services). This is due in part, to faulty information and engineering data provided estimators during early phases. Figure E.9 shows in bar graph form, a comparison of the SEA 01G estimate and actual return costs thru March 1977. Return costs for some areas of basic construction, i.e., auxiliary systems, command and control are, thus, far less than original estimates. But since estimated total basic construction labor-hours have already been exceeded, it should be noted that labor-hour overruns have occurred in the areas of integration engineering (design engineering) and ship assembly (construction services).

FIGURE E.9

ANALYSIS OF BASIC CONSTRUCTION LABOR HOURS



SOURCE:
BIW COST PERFORMANCE
REPORTS

- Integration Engineering estimates have been exceeded thus far by 174 thousand labor-hours, a 104 percent labor-hour growth. The Ship Assembly estimates have been exceeded thus far by 420,000 labor-hours or 153 percent.

. As of April 1977, the basic construction categories of Command and Control, Auxiliary Systems and Armament were significantly under the original estimates.

  - Command and Control were estimated at 200,938 labor-hours by SEA 01G while current return costs show only 43,192 labor-hours expended thus far; 79 percent under the original estimate.

  - Auxiliary Systems return costs are 99,000 labor-hours below estimates. The original estimate was 274,275 labor-hours and actual costs thus far have been 175,275 labor-hours.

  - Armament estimates thus far are approximately 28,000 labor-hours too high (01G estimate of 40,000 labor-hours versus 12,000 labor-hours return costs). The original BIW bid estimate for armament was close to 30,000 labor-hours, which is 18,000 labor-hours above current return costs.

Labor rates were also underestimated with the result that the increased labor-hours plus increased rates account for the significant labor dollar increase. NAVSEA 01G based their lead ship labor estimates on a rate of \$4.30/hour. Bath Iron Works projected a labor rate through completion of construction to be over \$6/hour. Labor rates, therefore, were under-estimated by almost 44 percent. Labor rates were increased at Bath Iron Works during lead ship construction. Available data does not indicate that the Navy estimate made any provisions for possible labor rate increases or was there

any data explaining the use of the $4.30/hour figure.

The following bar graph is a comparison of NAVSEA 01G material estimates versus the return cost data for material through March 1977.

- EACs for total material costs of $28.7 million (based on 82 percent complete) versus NAVSEA 01G estimates of $22.6 million show a difference of $6.1 million -- a 27 percent overrun.

- The initial bid by BIW estimated total material costs at approximately $23 million. The BIW figure was not exceeded until the contract was approximately 50 percent complete.

- A major portion of the material cost overrun occurred in the auxiliary systems. The NAVSEA 01G estimate was approximately $2.1 million and return costs through March 1977 exceeded $6.4 million, a $4.3 million overrun.

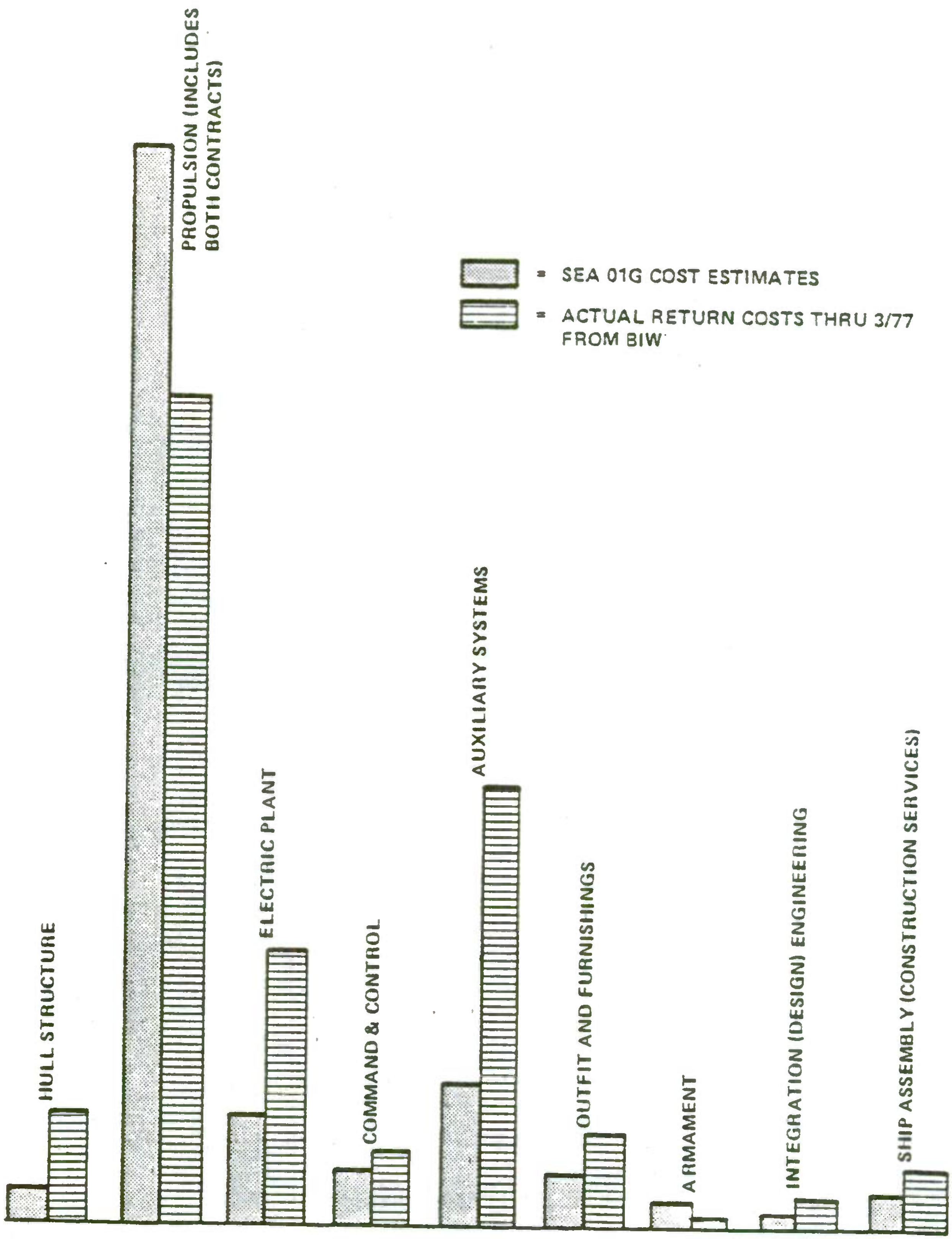
- The propulsion material costs under both the CPFF and CPIF contracts are less than the original estimates by approximately $3.6 million according to return cost data thru March 1977.

Further analysis of return cost data shows overhead costs of $10.3 million through March 1977, whereas NAVSEA 01G estimated $4.8 million for overhead costs. The April 1977 EAC projects overhead costs to exceed $17.1 million. Thus, there could be a 252 percent cost growth in overhead dollars.

The overhead estimates were very low in the cost categories of integration engineering (design engineering) and ship assembly (construction services), as shown in Figure E.11. It is noted that the same two categories were cost drivers in the labor-hour growth which was discussed previously.

FIGURE E.10

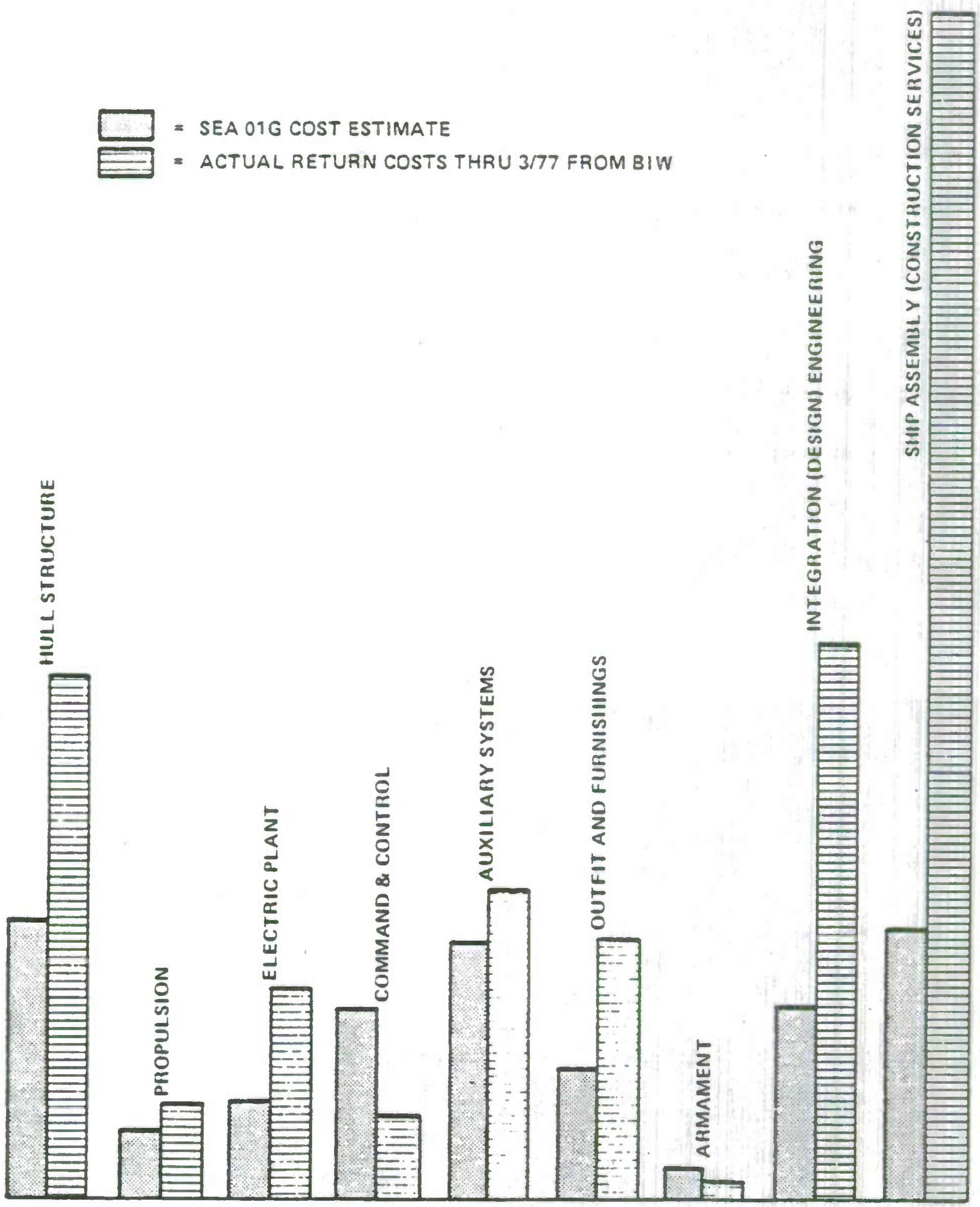
ANALYSIS OF BASIC CONSTRUCTION MATERIAL COSTS



SOURCE:
BIW COST PERFORMANCE REPORTS

FIGURE E.11

ANALYSIS OF BASIC CONSTRUCTION OVERHEAD COST $



SOURCE:
BIW COST PERFORMANCE REPORTS

11. IN ADDITION TO BASIC CONSTRUCTION COST GROWTH, THE GROWTH IN GOVERNMENT FURNISHED MATERIAL COSTS WAS SUBSTANTIAL

The largest single cost increase in GFM occurred in the area of Hull, Mechanical and Electrical in 1973 when estimates increased from $6.8 million to $29.7 million. The majority of this increase is attributed to test and instrumentation costs incurred at the propulsion system land-based test site. This included design, construction, hardware installation, and test. The majority of the remaining increases to present budget estimates is also in a large part due to additional test and instrumentation costs at both land-based test sites (i.e., $13.6 million).

In May 1972 the CNO promulgated several changes to the approved ship's characteristics as summarized below:

- Operate and support two vice one LAMPS helicopters
- 76 mm Oto-Melara Gun vice 35 mm gun
- SQS-505 Sonar vice SQQ 23 Sonar, later changed to the SQS 56 Sonar

Other than these changes, the weapon and sensor characteristics have remained relatively stable. It would appear, however, that the magnitude of testing costs were not foreseen in the original estimates. Equipment hardware costs and related software and testing costs have also increased, as shown in the following tables. (Table E.51 and Table E.52.)

TABLE E.51

HARDWARE COST INCREASES
(Millions of Dollars)

Equipment Designation	Budget Estimate (1/71)	Current SPD Estimate	Dollar Difference	Percent Difference	Reasons for Change
MK-92 Mod.2 Fire Control System with STIR	11.5 for one 15.7 for two	19.5(3) for two	3.8 (3)	24 (3)	1 LBTS System ($4.2M), additional GFE, INCO spares, systems engineering, console modifications, refurbish to "as new condition", portion of reliability testing.
MK-13 GMLS	5.4 for one	6.3 for one	0.9	17	Low estimates due to smaller initial quantity (one) buy than anticipated originally (50).
AN/SPS-49 Radar	0.825 for one	1.6 for one	0.775	94	Low estimates, undefine cost growth, engineerin services, contract increase to ceiling pric
HARPOON Command and Launch Subsystem (1)	0.100 for one	0.963 for one	0.863	863	Originally low estimates, poorly defined initial requirements, escalation.
AN/SQS-56 Sonar	1.5 (2)	2.3	.80	53	Additional testing or equipment modifications low estimates.

(1) No documentation available to support changes.
(2) Planning estimates
(3) Includes procurement of two MK 92 systems.

TABLE E.52

SOFTWARE AND TESTING COSTS
(Dollars in Millions)

Equipment Designation	Date of Increase	Amount of Increase	Reason for Increase
MK-92 FCS	late 1975	2.1	Reliability and qualification testing
	1976	1.3	Computer program support and engineering change proposals
MK-13 GMLS	since 1973	0.019	RMA testing
	late 1975 and 1976	1.6	Engineering support, strike impact, increase in scope, i.e., heat exchanges, spares, etc.; blast test vehicle, MK 60 testing
AN/SPS-49 Radar	After 1973	0.65	Deficiency correction, i.e., receiver noise, memory cards, additional operational testing, drawing revisions
	Total	5.7	

It should be noted that the FFG SHAPM originally requested Research and Development funds to finance the additional testing and reliability requirements for such items as the MK 92 Fire Control System, AN/SQS 56 Sonar and AN/SPS 49 Radar. Research and Development (R&D) funds were also requested for the land-based test sites on the basis that they were a form of research and development. The request for R&D funding was not approved with the result that a great deal of the testing was necessarily charged to lead ship construction -- in amounts not provided for in the original estimate.

Additionally, the cost growth experienced in the GFM area is not defined in much detail prior to 1975. Up until this time, the monitor on GFM cost increases was not stringent and detailed explanations for additional funds were not required.

(1) <u>The Navy Compromised One Of Its Conceptual Parameters For The FFG By Selecting The MK 92 FCS And SQS 56 Sonar</u>

During the conceptual phase in January 1971 a decision was made to make the FFG an "austere" ship, using wherever possible off-the-shelf items and only thoroughly tested weapons systems. In support of this concept, the original FFG plan called for the MK 87 FCS (CWI with STIR) or the MK 74 Fire Control System. The MK 92 FCS had recently been "Americanized" and installed on the PHM, but had not yet been service tested.

Three Sonars were reviewed as candidates for FFG installation. The SQS 505 was rejected because of high cost and failure to meet performance specifications. The SQQ 23, a logical candidate, was ultimately rejected because of high costs. The SQS 56, a modified version of Raytheon's commercially developed DE-1160 Sonar, even though not thoroughly tested, was selected because of its availability and favorable cost. The SQS 56 has experienced numerous problems, which include false detections, a detection distortion apparently

caused by a faulty dome and a range shortfall. As of July 1977 the SQS 56 was still not ready to be installed on the FFG 7.

12. THE FOLLOW SHIP CONSTRUCTION PHASE HAS BEGUN AND PROGRAM OPTIMISM IS SHARED BY ALL BUILDERS

The problems of lead ship construction, drawing validation, etc., would appear to have been worthwhile. Complete (but still changing) engineering drawings are in the hands of the follow ship contractors. The basic construction baseline would seem to be solid, with current changes restricted to final outfitting activities. The cooperation exhibited during the SSD phase continues. Todd Shipyards has assigned management and engineering personnel at BIW to monitor construction activities, and generally, both BIW and Todd share the view that the follow ship program should be profitable to their companies. It is too early to get sufficient data which would confirm or dispute these views. If further engineering and GFM changes are minimized, early project objectives can be realized.

The FFG 7 is currently scheduled for delivery during December 1977. The propulsion system continues to experience problems, along with the sonar which will not be completely installed upon delivery. Validated Drawing activities continue to have high priority since follow ship production is underway and engineering changes are still required.

One area of risk would seem to be a potential for further problems. The delays experienced during lead ship construction have caused lead ship trials to be scheduled for early to middle 1978. Completion of Validated Drawings cannot take place, therefore, before early 1979, some 12 to 18 months prior to projected delivery of nine follow ships. If trials go smoothly and no serious changes are forthcoming, no further delays are expected. On the other hand, if changes are required, a potential for cost overruns on these first nine follow ships may exist.

13. GROWTH IN TOTAL PROGRAM COST REFLECTS AN INCREASED UNIT PRICE PER SHIP, AN INCREASED INVENTORY REQUIREMENT AND ESCALATION

In late 1972 during FFG 7 budget reviews within the Navy, the projected total program costs for the 50 ship buy was $2,717,400,000. The FY 1978 budget shows a total program cost of $13,793,400,000 an increase of about 400 percent. Table E.53 tabulates this growth.

The first element of this increase is the growth in unit production cost per ship. Under the Design-to-Cost discipline, unit production costs are maintained in constant dollars. As engineering changes take place, applicable cost differences are applied in constant dollars so that the DTC goals or targets are maintained and remain visible.

TABLE E.53

GUIDED MISSILE FRIGATE SHIP DATA SHEET PROJECTIONS
(Dollars in Millions)

		FY 71	FY 72	FY 73	FY 74	FY 75	FY 76	FY 77	FY 78	FY 79	FY 80	FY 81	FY 82	FY 83	Unit Cost	Cost to Complete	Total Program Estimate***
1973	Quantity			1		7	11	10								21	50
	RDT&E	.9	11.7	1.5													14.1
	System Cost			191.5	82.0	347.5	531.9	436.8								1127.7	2717.4
	Outfit & PD****																
	TOTAL														54.63		2731.5
1974	Quantity			1		7	11	10	10							11	50
	RDT&E	1.1	11.5	1.5													14.1
	System Cost			202.2	6.8	416.9	609.5	555.4	596.0						64.61	616.9	3003.7
	Outfit & PD						.6	8.0	9.0							203.5	221.1
	TOTAL															820.4	3244.5
1975	Quantity			1		7*	11	10	10	11							50
	RDT&E		-12.6	1.5													14.1
	System Cost			202.2		436.5	655.9	614.8	623.7	699.0							3632.1
	Outfit & PD						.3	4.4	1.2	23.3						201.8	231 0
	TOTAL														69.70		**3482.8
1976	Quantity			1		3*	10	11	10	11	10						56
	RDT&E			14.1													14.1
	System Cost			205.6		186.0	955.5	1233.3	1112.0	1312.6	1208.2						6213.2
	Outfit & PD						1.3	5.8	0.4	14.7	69.9					368.8	460.9
	TOTAL														122.0		**6831.5
1977	Quantity			1		3	6	8	8	8	8	8					50
	RDT&E				14.1												14.1
	System Cost				205.6	186.0	802.5	1179.5	1171.6	1272.9	1333.3	1411.4					7562.8
	Outfit & PD						0.9	1.8	6.0	13.8	52.2	61.6				460.8	597.1
	TOTAL														169.5		8475.6
1978	Quantity					4	6	8	9	11	12	12	12				74
	RDT&E					14.0	0.1	1.0	4.2	2.8	1.4	0.2					23.7
	System Cost					391.6	802.5	1179.5	1319.0	1950.1	2222.0	2376.0	2514.0				12754.7
	Outfit & PD						1.0	1.7	10.8	13.8	45.1	71.1	90.2			504.9	738.6
	TOTAL														186.4		13793.4

*Congress reduced due to concern over the MK92 FCS
**3.483 to 6.831 change due to -- .386 for design changes, CIWS and revised GFE; Inflation 1.665 & schedule change 535=2,200; .762 for six more ships = 3.348
***Escalation amounts for prior years not included.
**** PD = post delivery

The Conceptual Report in July 1971 specified a Design-to-cost goal based on engineering data then available. Early program activities dealt with the process of evaluating trade-offs in operating characteristics, weaponry and major equipment to produce an acceptable capability for a cost at or under the cost goal. When the preliminary design was completed, a new DTC target was fixed. Once the single ship platform was selected and initial characteristics were approved, DTC goals were subsequently identified each time a major engineering or project change took place.

A summary of the major changes follows:

TABLE E.54

FFG DESIGN-TO-COST TARGETS FOR FOLLOW SHIPS
(End Cost)

Milestone	1973 Dollars (in millions)
Original Goal -- December 1970	50.0
Conceptual Baseline Goal -- July 1971	49.2
Functional Baseline Target -- August 1972	45.7
Updated Target -- October 1973	47.7
Updated Target (DSARC III) -- June 1976	71.3

The difference between an important DTC goal -- functional baseline -- of \$45.7 million and the lead ship baseline target of \$71.3 million, a \$25.6 million increase, has been explained by project officials as follows.

TABLE E.55

FFG RECONCILIATION OF DTC TARGET

Functional Baseline Goal (1973 Constant Dollars) $45.7M

Changes	$ M	%
Engineering	1.8	7
Estimating (GFE/CFE)	5.9	23
Characteristics and R/M/A	1.3	5
Market Factors	8.5	33
Revised Procurement	2.0	7
Revised Outlay Rates	3.0	11
Adjustment for Small Buy	3.1	12
Total	25.6	

New Design-to-Cost Goal (1973 Constant Dollars) $71.3M

By removing the adjustment for small buys, which is not pertinent if the proposed procurement plan is followed, the new DTC goal would equate to $68.3 million, an increase of 37 percent.

Although an increase of 37 percent would appear on the surface to be large, it must be understood that the increase is computed from an arbitrary goal which was established during engineering and prototype phases. In that time, many trade-offs and changes were made in order to maintain cost goals. Project officials have expressed the opinion that without the use of DTC techniques, the average follow ship cost might be considerably higher.

A second major element of cost growth is attributed to the increase in program size. The original inventory target was 50 ships. This number has

changed several times and now is planned at 74. The 24 ship increase extended the program for at least two full years. The unescalated cost of these ships is now estimated at $1.6 billion.

The third and largest component of cost growth is escalation. Prior to approval of the development estimate, escalation estimates were averaging approximately 5.8 percent of total program cost. The approved development estimate for escalation was established at $624.1 million which amounted to 19 percent of total program costs as of June 1974.

Escalation increased substantially with the June 1974 "current estimate" and showed further increases through March 1977. It then represented 57 percent of total program costs. Table E.56 tracks escalation increases to March 1977.

Figure E.11 summarizes program cost growth in major cost categories over the program life through March 1977.

14. IN SUMMARY, FFG PROGRAM TRACKING HAS IDENTIFIED PROBLEMS IN THE AREAS OF COST ESTIMATING AND MANAGEMENT STRATEGIES

Although it is very early in the total FFG program, findings and conclusions which are based mainly on lead ship experience are of sufficient importance to warrant comment relative to cost estimating and project strategies.

TABLE E.56

SUMMARY OF GUIDED MISSILE PATROL FRIGATE PROGRAM ESCALATION CHANGES

(Dollars in Millions)

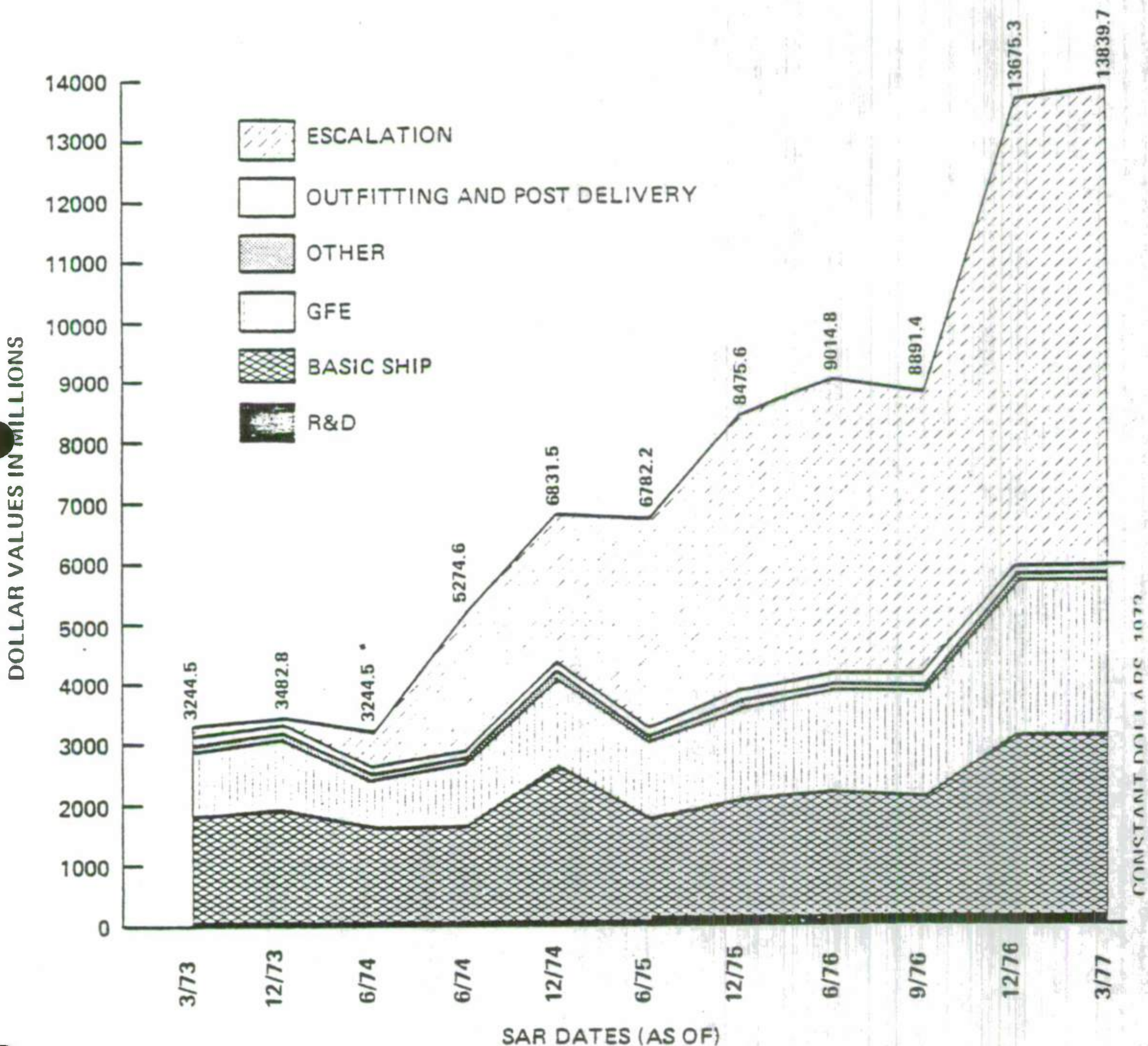
Total Program	Percent of Program	Dollars	Date	Explanation
3482.8	5.8	202.5	December 1973	1. Ship characteristic changes; 2. New material cost and productivity factors; 3. OSD inflation indices; 4. FY 74 Defense AppropriationAct denial of advanced procurement funding for FY 75 program.
3244.5	19.2	624.1	June 1974	1. Establishment of development estimate baseline for escalation.
5274.6	46.8	2466.8 (1)	June 1974	1. 1974 inflationary trend including utilizing later BLS indices and NAVSEA future economic forecast; 2. Previous engineering changes; 3. Additional diesel generator; 4. Revised GFM estimates. Last ship delivery now 4/83.
6831.5	36.1	2466.8 (2)	December 1974	1. Prepare and install Phalanx CIWS beginning with FY 76; 2) Extention of follow ship production due to FY 75 Defense Approriation Act from 7 to 3 ships; 3. Longer material and equipment lead times; 4. Change in procurement strategy; 5. Addition of six ships to FY 80 program. Last ship delivery now 1/85.
6782.2	48.7	3300.5	June 1975	1. Potential cost growth in lead ship cost type contract.
84‾5.6	53.9	4564.5	December 1975	1. Delete 6 ships added in 12/74 SAR, ; 2. Revised ship quantities; 3. Outfitting and post delivery requirements.
9014.8	53.5	4825.8	June 1976	1. Four ships added to FY 77 program; 2. Refining follow ship outlay rates.
13675.3	56.4	7717.6	December 1976	1. Additional 24 ships added to President's FY 78 budget submit; 2. LAMPS I electronics; 3. Lower escalation requirements for program years FY 75, 76 and 77. Last ship delivery now 2/87.
13837.7	56.8	7858.8	March 1977	1. President's amended FY 78 budget submit transferred two FFG's to FY 82; 2. Revised GFM; 3. Reduced competitive market for follow ships. Last ship delivery now March 1987.

(1) Escalation development estimate of $624.1 million established.

(2) The increase of $831.7 million in this quarter did not appear in escalation total until June 1975.

FIGURE E.12

GUIDED MISSILE PATROL FRIGATE DOLLAR GROWTH OF THE MAJOR PROGRAM CATEGORIES



* OFFICIAL DEVELOPMENT ESTIMATE

SOURCE:
FFG SELECTED
ACQUISITION REPORTS

With regard to cost estimating and financial management

- Current (April 1977) end cost estimatme projects a cost growth from the original estimate of 41 percent.

- The major contributors to cost growth by category are: basic construction, change orders, hull/mechanical/electrical, ordnance, and escalation.

- Using the initial budget estimates and the Bath Iron Works estimate at completion, basic construction cost growth (FFG 7) will exceed 70 percent.

- Analysis of basic construction cost growth reveals the following:

  - Labor-hours -- budget estimates exceeded by at least 91 percent; largely in the cost areas of integration engineering and ship assembly.

  - Labor dollars -- exceeded by 175 percent.

  - Labor rates -- budget estimates exceeded by approximately 44 percent.

  - Material dollars -- budget estimates exceeded by 27 percent.

  - Overhead dollars -- budget estimate exceeded by over 252 percent.

- Numerous change orders (HMRs/FMRs) during basic construction are expected to be responsible for over $18 million in cost growth. The 37 percent increase includes changes such as the addition of a fourth diesel generator, a fifth fire pump, longitudinal bulkheads, and a redesigned fire fighting capability, etc.

- The area of H/M/E experienced significant cost growth — a $36 million increase.

  - $23 million was due to additional test and instrumentation at the propulsion system LBTS.

- Lead FFG costs are high partly due to cost charges (including testing) for the propulsion and combat system LBTS. Since the follow ships will benefit from these test sites, their costs might properly be amortized over the entire program to reflect a more just situation.

. The ordnance cost category has experienced a growth of almost $14 million or 36 percent thus far.

- Major increases are in weapon and sensor hardware costs:

MK 92 FCS	24%
MK 13 GMLS	17
AN/SPS 49 Radar . . .	94
HARPOON Command and Launch Subsystem	863
SQS 56 Sonar	53

- Reasons for these increases were not well documented but included such things as 1) LBTS equipment; 2) additional spares; 3) low estimates; 4) engineering services; 5) additional GFE; 6) poorly defined initial requirements; 7) escalation.

- Additional software and testing costs have thus far resulted in large increases in weapon and sensor costs totalling almost $6 million.

. Denial of R&D funds for the additional testing and modifications to such items as the MK 92 FCS and AN/SQS 56 Sonar contributed to cost growth.

. Estimates for detail design have proven reasonable.

- Based solely on budget estimates detail design costs will be $6.4 million under the original budget estimate.

- The cost growth between the contract price and current (April 1977) Bath Iron Works end cost estimate at completion is $20.9 million.

- Changes caused by defective NAVSEC specifications, validated drawing concept, changes in ship design (engineering changes), etc., contributed to the cost growth.

. Escalation has been a major factor of cost growth.

- Impact of escalation on lead ship costs is difficult to determine since escalation is included in each cost category.

- Escalation growth allowances on 74 ship FFG program has increased $7.2 billion since the approved development estimate, a percentage increase of over 1,100.

With regard to project and management strategies,

. Design-to-Cost goals included ship design austerity, use of off-the-shelf items and service tested weapon systems. These goals could not be totally implemented in the final lead ship design because of required characteristic and design changes.

. The Design-to-Cost dollar goal was optimistic, set too early and taking DTC in its strictest interpretation, did not keep design costs close to initial goals. Design-to-Cost goals can be self-defeating if established prior to a firm ship definition.

. The Design-to-Cost dollar goals established cost constraints which exerted pressure to minimize costs and maintain cost consciousness throughout a program, especially during the conceptual design phase.

. The use of land-based test sites promises to be a positive cost control factor.

. The use of the validated drawings concept will be proven or disproven as a cost control factor as the construction of the follow ships progress, but currently is seen as a positive project technique.

- The use of the central procurement (standardization) concept may not reflect a positive cost control factor, but will aid in having standardized ships in a class and decrease life cycle costs through a better availability of spares and lower maintenance costs.

- The compression of the time interval between lead and follow ship construction tends to lessen the positive cost control aspects of the FFG acquisition strategy.

CHAPTER VI

CASE HISTORIES -- GOVERNMENT FURNISHED MATERIAL

The end cost of a combatant ship generally includes a component of at least 30 percent for the cost of Government Furnished Material. This cost is comprised of the basic procurement cost plus a series of installation, accessory and engineering costs. The GFM supplied spans the spectrum from nuclear or conventional propulsion to weapons, radars, fire control systems, computers, etc.

Since GFM comprises so large a portion of the total ship cost, detailed analyses have been performed on eight different items of GFM.

- AN/SPS-55 Surface Search Radar
- AN/SPS-40 Air Search Radar
- 5"/54 Caliber Lightweight Gun MK 45
- MK 86 Gun Fire Control System
- AN/SQS-53 Sonar
- PHALANX - Close In Weapons System (CIWS)
- AN/UYK-7 Digital Computer
- LM 2500 Gas Turbine Engine

These systems were reviewed to determine the accuracy of estimates for each type of equipment and; if overruns occurred, what some of the causes might be.

These systems range from being in the development stage to having been procured under several production contracts over a number of years.

Therefore, the amount of documentation covering early estimating that is available for review varies widely from system to system. Moreover, there were organizational and cognizance changes which contributed to the paucity of records available for some of the systems. Nevertheless, sufficient information was available to permit identification of basic problem areas affecting the quality of estimates for Government Furnished Material.

1. THE AN/SPS-55 IS A CONVENTIONAL X-BAND SEARCH AND NAVIGATIONAL RADAR FOR USE ABOARD NAVY SURFACE SHIPS

The AN/SPS-55 is a conventional X-band search and navigational radar for use aboard Navy surface ships. The overall characteristics of the radar provide greater accuracy for close-in navigation than the AN/SPS-10. The requirement for the AN/SPS-55 radar originated in OPNAV (OP 03) in the early part of FY 1963. It was not developed for installation on a specific class of ships, but rather, to take advantage of evolving technology which included solid state construction and higher frequencies for improved range and reduced weight. The OPNAV/NAVSEA transaction was based on an informal request, rather than through the Specific Operational Requirement (SOR) process.

The original design was funded by RDT&E Engineering Development funds (Budget Activity 6.4) in FY 1963 since the required equipment was essentially within the state of the art and risk was minimal. The capability

required was defined as being generally similar to that of the AN/SPS-10 except that the new radar would operate in X-band rather than the C-band. The development was initiated in 1963 under a performance specification and the original design equipment, produced by Raytheon, was service approved in 1968. In late 1969, the decision to use this radar on the DD 963 class and the DLGN 38 class (now CGN 38) was made. At this time, the design was reviewed, the transmitter and receiver were combined into one cabinet, and a circuit involving suppression of clutter was removed. The design has been stable since and consists of:

- Receiver/Transmitter RT-1124/SPS-55
- Antenna Group OE-172/SPS-55
- Antenna Safety Switch SA-1963/SPS-55
- Radar Set Control C-9447/SPS-55

Other equipment such as displays and repeaters are not a part of the basic AN/SPS-55 system.

(1) An Historical Track Of The Estimate Is Not Possible Before 1972 Because Of Lack Of Records And Inconsistency IN Estimating Format

The earliest available cost estimate for the AN/SPS-55 radar amounted to $80,000 per system for the DX and DXG classes of ships. The office provided the cost estimates was identified by forwarding letter PMS-89 DX/DXG serial number 0214 dated March 26, 1969

(the DX became the DD 963 and the DXG the CGN 38) but relevant fiscal year information was not provided. The next estimate of $50,000 per system was included in the FY 71 requirement list of electronics (undated) for the LSD ship class. The above cost information was found in NAVSEA 01G ship files and was used by NAVSEA 01G (then NAVSHIPS 05F) in the budget process. These were the only two estimates still on record prior to December 1976 which were not generated by NAVSEA 01G. They were neither uniform in format nor broken down into the various cost categories such as basic hardware, engineering, spares, installation and technical manuals. Therefore, there was no basis for a cost analysis.

This breakdown of information should be found in the AN/SPS-55 Radar files of the project engineer, however, a search of those files revealed no historical cost estimate data. The absence of cost estimating documentation may be attributable to the relatively low cost of the system, now approximately $100,000 for the hardware; and did not, therefore, require implementation of the various directives and instructions concerning return cost data, maintenance of data banks and cost tracking. No cost data bank has been maintained by the project manager or other offices involved in the radar's acquisition. Rather, reliance on previous contract costs is standard operating procedure.

The only Budget/POM estimates which were promulgated by the AN/SPS-55 project office, were forwarded on December 28, 1976 to SEA 01G. The estimates were in FY 77 and 78 dollars and the unit costs were as follows:

TABLE E.57

PROJECT OFFICE ESTIMATES FOR AN/SPS-55
(Dollars in Thousands)

	FY 77	FY 78
Hardware	$ 99	$101
I & C Spares	29	34
Systems Engineering Costs	9	13
SQT Costs		5
Project Management	45	49
TOTAL	$182	$202

These estimates did not specify a ship or ship class or the number of systems to be acquired.

(2) The SEA 01G Records Show A Basic Hardware Cost Growth Of 62 Percent Over Five Fiscal Years

The following Table E.58 shows the NAVSEA 01G estimates on record for the DD 963, DE, CLGN-AEGIS, PCG, PGG, DDG, and CGN 9 classes of ships.

These figures provide a uniform cost estimating history of the AN/SPS-55 system since 1972. Since the radar system was well defined and contracting information was readily available, the estimates

TABLE E.58

NAVSEA 01G COST ESTIMATES FOR THE AN/SPS-55 RADAR
(Dollars in Thousands)

	DD 963 CLASS			FF CLASS (DE)	CLGN (AEGIS)		PCG & PGG	CGN 9, DDG
	December 22, 1972			June 21, 1973	June 17, 1974	June 4, 1975	Nov. 11, 1975	Nov. 11, 1975
	FY 73	FY 74	FY 75	FY 75	FY 76	FY 77	FY 76	FY 78
Hardware	65	70	73	74	89	100	85	105
Initial Spares	5	5					16	20
Field Engineering Services								
Design Engineering Changes	2	2	5	1	7	15	18	22
I & C Spares				6	10	22	3	4
Contract Field Eng. Services				2			2	3
Government Field Eng. Services	2	2	6			25	3	4
Tech. Data and Documentation				1			2	3
System Engineering Costs				10	8			
SQT Costs				6				
Project Management							9	8
Systems Test and Evaluation							3	4
ILS Manage							2	3
TOTAL	74	79	84	100	114	162	143	176

subsequent to 1972 in general reflect only the annual mark-ups for inflation on the previous year's estimate. A lack of detailed data in the SEA 01G or project office files prevents an analysis to identify the causal factors for increases in basic hardware (62 percent), in initial spares (300 percent), and in design engineering services (1000 percent). Although the estimate of the total cost increased from $74,000 in FY 73 to $176,000 in FY 78 (137 percent), the cause of the increase was a cumulative result of increases in various cost elements and not a specific cost driver. For example, the basic hardware cost estimate increased from $65,000 in FY 73 to $105,000 in FY 78 (62 percent) or at an approximate annual rate of 10.5 percent, paralleling the average annual inflation rate of the period. As evidenced by the CARDION contracts for $92,000 (1976) and $86,256 (1977) per set (hardware), the above FY 78 hardware cost of $105,000 is reasonable. Of the $176,000 total estimate for FY 78 (CGN 9, DDG) $41,000 are for non-related contract items such as a reserve for engineering changes, government field engineering services, etc. The SEA 01G total estimates made in 1975 are therefore, not excessive.

(3) <u>There Has Been Only One Contract For The Radar System Which Was Awarded By Competitive Bidding, While Subsequent Contracts Were Sole Source</u>

Cardion Electronics, in May 1971, was awarded the first contract in competitive bidding (including Raytheon) for 36 AN/SPS-55

Radars. The contract was fixed price with the basic hardware costs of $41,800 per unit and the Installation and Checkout (I&C) kits priced at $5,000 per unit. These radars were originally acquired for installation on the DD 963 and CGN 38 classes but those for the CGN 41 and 42 were subsequently diverted for the FFG 7 and for use at a Navy training site.

A second contract to Cardion was awarded in April 1976 as sole source for 18 radars under a Foreign Military Sales Program (Saudi Arabian Navy). The basic hardware cost was for $91,500 per unit and the I&C spares were $6,943 per kit.

A third contract to Cardion, again as sole source, was awarded in mid-June 1977, for the FFG 7 class and for the CGN 41 and 42. A PMS 399 Memo of March 17, 1977 referring to the mid-June award stated that "the proposal (by Cardion) was at $93,600 per unit"; however, the contract price was negotiated for $86,256 per unit (hardware).

Detailed data was not available for analysis, therefore, it is not possible to identify the factors which directly contributed to the radars' cost increase of 119 percent (approximate rate of 24 percent per year) for the five year period between the May 1971 and the April 1976 contracts. The cost increase from 1971 to the June 1977 contract is 106 percent or 18 percent per year. If any conclusion is to

be reached it would have to cite the probable advantages of competitive vs. sole source bidding for contracts, although other factors along with competitive bidding may have been the reason for the relatively low cost of the first acquisition.

Figure E.13 compares the three contract award prices with the related estimates by ship class and fiscal year designation.

FIGURE E.13
AN/SPS-55 RADAR

TREND IN BUDGET ESTIMATES AND CONTRACT AWARD PRICES (BASIC HARDWARE ONLY)
(Thousands of Dollars)

Item Description	Est. For	Est. Date	FY Applicable	Amount Estimated	Amount Contract Award
SPS-55			71		41
	DD 963	12/72	73	65	
	DD 963	12/72	74	70	
	DD 963	12/72	75	73	
	DE	06/73	75	74	
	CGN*	06/74	76	89	92
	PCG/ PGG	11/75	76	85	
	CGN*	06/75	77	100	86
	CGN 9/ DDG	11/75	78	105	

* Formerly DLGN

(4) <u>No Independent Cost Estimates Are Presently Being Generated For The Radar; Specific Reasons For The Cost Growth Can Not Be Ascertained Due To The Lack Of Documentation</u>

In developing the cost history, we found that records did not exist in any consistent manner prior to 1972 and that the project office does not retain cost estimating information. This can be attributed to the fact that the AN/SPS-55 is a relatively old system and that there were documentation retention problems resulting from the relocation of offices, changes in technical and administrative cognizance and records disposal efforts. The AN/SPS-55's odyssey is noted here because it is typical of many GFM items and has resulted in the loss of valuable information. The AN/SPS-55 was developed by the Bureau of Ships which became the Naval Ship Systems Command and cognizance remained there until 1969. Further, internal components of NAVSHIPS were split off to establish the Naval Ship Engineering Center (NAVSEC) which was physically located in Hyattsville, Maryland and had cognizance of this radar. In 1972 program management responsibility for certain search radars including the AN/SPS-55 was transferred to Naval Ordnance Systems Command (NAVORD) with the technical responsibilities for the radar remaining in NAVSEC. In 1976, NAVSEC was absorbed in the Naval Sea Systems Command and relocated to Virginia. Research of the available files show that technical records were retained throughout the many office and per-

sonnel changes, but the cost estimate information was evidently lost or discarded. After 1972, the SEA 01G records do provide cost estimate information. As borne out by interviews and documents, these estimates are simply the sum of the previous year's estimate plus additional money for expected cost increases over the next year. None of the estimates indicated the basis for the cost increases other than as being the results of the general economic trends.

(5) Although The Estimating Process For The AN/SPS-55 Radar Is Not Very Structured, Reasonably Accurate Estimates Do Result

The organizational structure and staffing of the project office is not oriented for cost estimating the AN/SPS-55 Radar. The technical descriptions of the radar are good and readily available. However, there was no evidence of cost data banks or return cost information upon which analogous cost estimates could be derived or cost analyses made. What cost estimate information is available is fragmented throughout the SEA 02 contracts, the SEA 01G historical Program Year and Ship files, and the SEA 01G AN/SPS-55 Radar files.

For relatively small and inexpensive hardware, such as the AN/SPS-55 Radar, cost estimating within NAVSEA is not a structured process. Cost estimating in these cases is generally done by contacting

the vendor or by reviewing past contract prices and adding inflation factors.

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The following is a summation of the cost estimating process for the AN/SPS-55 Radar.

- Staffing and Organizational Structure -- there is none for estimating the cost of the AN/SPS-55 Radar in the POM/ Budget process.

- Data Banks -- no actual cost data banks could be found for AN/SPS-55 Radar. Data could only be found in the various NAVSEA 01G files and NAVSEA 02 contract files and the data available was neither organized nor consistent in format.

- Return Cost -- none was available other than that provided by the procurement contracts.

- Escalation and Inflation Predictions -- NAVSEA 01G appears to be the only office undertaking this function.

- Quality Versus Technical Data -- due to the age and level of technology employed in the radar design, the technical information available is complete and accurate. This information is not used, however, in estimating for the radar.

- Estimating Response Time -- this could not be determined in any detail, but as the estimates generated are simply mark-ups of existing figures, it appears the time required is minimal.

- Review Procedures -- There does not appear to be any procedure for reviewing accuracy of cost estimates for the AN/SPS-55 Radar.

- Technical Complexity of Estimates -- since all estimates are the result of mark-ups for inflation to the latest contract costs, complexity in the estimates is not a factor.

2. THE AN/SPS-40 RADAR DATES FROM THE LATE 1950's AND HAS EVOLVED INTO THREE DIFFERENT CONFIGURATIONS OVER ITS TWENTY YEAR HISTORY

In response to a CNO operational requirement for a lightweight air search radar to be installed on a destroyer, the AN/SPS-40 was developed in the late 1950's and early 60's. It was submitted to technical evaluation and operational evaluation from September to November 1960, recommended for service use in January 1962 and approved for service use by the CNO in May 1962.

The original design employed vacuum tube technology even though it was developing during the transitional period when electronic equipment was changing to solid state technology. During 1964-65 improvements were made in the AN/SPS-40's design, including the adaptation to a broad transmitter chain requiring a minimum of adjustments, utilization of ultrasonic disperse delay lines in the pulse compression circuitry, and incorporation of solid state design into the signal processing circuits. The AN/SPS-40 was then designated the AN/SPS-40A. During 1968-69 the AN/SPS-40A was again partially re-designed. This resulted in increasing the mean time between failures (MTBF) to 200 hours, decreasing the mean time to repair (MTTR) to two hours, more extensive use of solid state circuitry and the addition of the low flyer detection modification (LFDM) to improve the minimum range capabilities and detection of small, low-flying, high-speed targets. These new capabilities resulted in

a change of designation to the AN/SPS-40B and the design has remained stable since that time. It should be noted that further production of the AN/SPS-40B is being discontinued as the AN/SPS-49 is being installed on new ships in its place.

As of June 1970, 130 major improvement kits had been ordered from Dynell Electronics for use in updating the AN/SPS-40's and AN/SPS-40A's to the reliability and performance level of the AN/SPS-40B. The converted AN/SPS-40 is designated AN/SPS-40C and the AN/SPS-40A is designated AN/SPS-40D.

(1) The Cost Estimating Performance For This Radar Has Been Adversely Affected By the Repeated Organizational Changes In the Navy And Configuration Changes Of The Radar

As might be expected, initial cost estimates (planning or development estimates) for an equipment in production since 1959 could not be found, the situation being similar to that involving the AN/SPS-55 radar. The present project engineer in NAVSEA stated that there was no cost estimate data in his office and the only known source of cost data was in the AN/SPS-40 contract files in the Contract Office, NAVSEA 02, and in the procurement files of SEA 04. He also stated that his cost estimates for the AN/SPS-40 configurations were based on the last contract and his own judgement including his own escalation factors. The project engineer indicated

that he might have some input and be consulted during the contracting process, but that cost estimating is not his primary concern. The only sources of early cost estimates for the AN/SPS-40 were the NAVSEA 01G ship program year files, various NAVSEA 01G ship files, and contract files. The earliest estimates still available are as follows:

TABLE E.59

EARLY ESTIMATES FOR THE AN/SPS-40 RADAR

Configuration	Document	Date	Applicable Ships	Fiscal Year	Cost Estimate/ Per Unit
AN/SPS-40	BUSHIPS D&F No. 63-835	March 13, 1963	LPD, LPH, FF, (DE 1052)	--	$149,545
AN/SPS-40	Computer Read out Sheets	Oct. 5, 1964	LPD, FF (DE 1052) and LSD	FY 66	$212,000
AN/SPS-40A	P1 sheet Procurement Program	April 30, 1965	FF (DE 1052)	FY 66	$212,000
AN/SPS-40B	NAVSEC Memo 6200 Ser. No. 6271-04	June 9, 1967	LCC, LHA	FY 69	$160,000
AN/SPS-40B	Schedule A	June 9, 1967	CGN (DLGN) Class Ships	FY 70	$160,000
AN/SPS-40	ltr. PMS 389 DX/DXG ser. No. 0215	April 16, 1968	CGN Class (DXG) DD 963 class (DX)	FY 66	$152,990

The records did not reveal why the cost estimates varied, or whether the cost was for only the basic hardware or if additional items were included. The records were not uniform in format and it would seem that estimating was not performed on a regular basis. Only the earliest estimate listed in Table E.59, indicates the nature of the estimating process and what was included in the estimate. Specifically, it stated, "[The estimate is] Based on previous awards and an engineering estimate", that the figure includes, in addition to the basic hardware, "antenna assembly, test, repair parts, and technical data and reports." None of the other early estimates contained any information of this nature. The use of the cost estimates on the preceding page as the initial point from which to track the cost history is questionable, yet is the only data available.

All the above cost information was used by NAVSEA 01G (then NAVSHIPS 05F) for the Program Objectives Memoranda and budget estimates until 1971. At this time (1971), program management responsibility for search radars was given to NAVORD.

The following cost information for the AN/SPS-40B was forwarded by an unknown office in NAVORD to what is now NAVSEA 01G in December 1972 for the DD 963 ship class. They are the earliest NAVORD cost estimates recorded in NAVSEA 01G equip-

ment files and include costs additional to hardware.

TABLE E.60

NAVORD AN/SPS-40B COST ESTIMATES
(Dollars in Thousands)

	FY 73	FY 74	FY 75
Hardware	$200	$214	$229
Initial Spares	20	22	22
Project Management			
Government Field Engineering Services	15	16	17
Design Engineering Changes	15	16	17
Total	$250	$268	$285

SEA 01G's first estimate for the AN/SPS-40B radar still on record for radars to be installed on the FY 76 PCG class of ships is detailed in Table E.61. The latest existing estimate for the AN/SPS-40B radar generated by SEA 01G is for ships of the FY 77 LX-1 and PCG ship classes and is also listed in the following table.

These estimates are puzzling in that they demonstrate a difference in expected total cost of $406,000 (76.6 percent increase) for the same radar. Although the earlier estimate is calculated in FY 76 dollars and the later one in FY 77 dollars, this could not account for a difference of this magnitude. The last column in the table indicates

TABLE E.61

NAVSEA ESTIMATES FOR THE AN/SPS-40B
(Dollars in Thousands)

	PCG Class FY 76 11-12-75	LX 1 PCG Class FY 77 12-5-75	Difference in Estimates (FY 77 - FY 76)
Hardware	367	659	292
Initial Spares	37	50	13
Installation & Checkout	37	25	-12
Design Changes	--	66	66
Test Equipment	--	14	14
Project Manager	18	--	-18
Contract Fld. Eng. Serv.	20	6	-14
Gov. Fld. Eng. Serv.	30	6	-24
Design Engineering	--	--	--
Technical Data and Doc.	13	5	-8
Integrated Logistic Support	4	--	-4
Systems Eng. Cost	--	75	75
SQT	--	30	30
QA & RMA	4	--	-4
TOTAL	$530	$936	$406

the changes in estimated cost, but no further elaboration on why these changes were instituted exists. All that can be surmised from the data available is that certain line items in the estimates were revised upwards or downwards; and no conclusion can be drawn as to the reasons for the change or why one estimate includes certain line items while the other does not. Thus, this situation requires that any further evaluation of cost estimates be limited to hardware and spare parts.

(2) <u>Actual Cost Growth Of The Radar Has Been Minimal Until The Most Recent Contract In 1976</u>

The first production contract was awarded in 1959 to Lockheed for 92 AN/SPS-40 systems at an average unit cost of $143,606. The radars were acquired for installation on the LPD, DE 1052 and LSD classes of ships. Although the contract files and other sources were scrutinized, no documentation of unit cost changes in this contract could be found. This would indicate that there were no cost changes over the course of this contract and the unit end cost was $143,606.

The second contract was awarded to Lockheed Electronics in 1963 for the procurement of 47 AN/SPS-40 radars at an initial unit cost of $158,086. These radars were acquired for installation aboard the DE, DDR, LPD and LPH ship classes. Although documents in the remaining contract files show that the final unit cost was $187,189 on completion of the contract in 1967, documentation concerning the reasons for this increase in cost (18 percent) could not be found as most of the contract files are no longer in the Navy Archives. This acquisition was a sole source acquisition for the AN/SPS-40 radar and was due to "... urgent requirements; Lockheed is the only previous manufacturer and the only one in a position to make early delivery," according to a NAVSHIPS 4494-7 Procurement Request of September 20, 1962 found in the contract files.

In 1965, Sperry Marine was awarded the first contract for the AN/SPS-40A configuration following competitive bidding. The contract was for 72 radars to be acquired at a unit cost of $167,000 and to be installed on ships of the AGC, LHA, DLGN and DX/DXG classes. Over the course of this contract, the unit cost increased to $192,020 (15 percent); the result of specification, engineering and requirement changes.

TABLE E.62

COMPARISON OF AWARD WITH CURRENT END PRICES
AN/SPS-40 RADARS

Contractor	Year	Configuration	Quantity	Unit Price: Award Price	Unit Price: Current End Price
Lockheed	1959	AN/SPS-40	92	$143,606	$143,606
Lockheed	1963	AN/SPS-40	47	$158,086	$187,190
Sperry Marine	1965	AN/SPS-40A	72	$167,000	$192,020
Dynell Electronics	1969	AN/SPS-40B	46	$190,728	$214,760
Dynell Electronics	1976	AN/SPS-40B	7	$455,300	$455,300

Dynell Electronics was awarded the first procurement contract through competitive bidding for the AN/SPS-40B configuration in 1969. This contract also included provisions for 130 modification kits to be used in updating the existing AN/SPS-40 and AN/SPS-40A configurations to the AN/SPS-40B configuration. The initial unit cost was

$190,728 for 46 radars intended for installation on the DDG, DD 963, AOE and LX classes of ships. So far the average unit cost has increased to $214,760 (13 percent) and, again, the increase has been attributed primarily to design, engineering and specification changes in available contract documentation.

The latest contract was a sole source award to Dynell Electronics in December 1976 for seven radar systems and their support equipments. The unit hardware cost was $455,300. These radars are being acquired for installation on the PCG (foreign military sales) and CGN 41 ship classes.

Not very much can be learned from these except that the costs over the period 1959 through 1969 grew at a reasonable rate (three or four percent) per annum. However, the cost growth in certain contracts might have been anticipated through more careful estimating. The latest, higher contract price appears to be the result of inflationary factors (at least 75 percent between 1969 and 1976) and a sole source, small buy. Also a factor is that certain of these radars are for foreign military sales which have unusual cost features.

In sum, the absence of documentation presents difficulties precluding thorough examination of cost drivers in the procurement pro-

cess of the AN/SPS-40 configurations. However, when consideration is given to the generally nominal price increases in this system, the economic trends of the times, variations in size of the acquisitions and the extensive design changes this radar has undergone, it appears that there were no specific cost drivers within the radar's design and that the price increases were apparently the result of the influences of the economy.

(3) <u>The Accuracy Of The Existing Estimates Is Low Throughout The History Of The Radar Reflecting A Continual Lack Of Interest And Effort In Estimating For The AN/SPS-40 Radar</u>

Cost estimates for the AN/SPS-40 radar prepared more recently have been based primarily on judgement, derived from information provided in former contracts. The necessity for detailed and extensive estimates was precluded by the repeated use of competitive bidding for contracts, which also appeared to have been partially instrumental in keeping the price increases down.

The rationale behind the AN/SPS-40 Radar cannot be evaluated since, as indicated previously, the AN/SPS-40 configuration has undergone numerous changes and no original estimates remain for these configurations. However, it is possible to demonstrate the approximate level of the cost estimating capability by comparing the earliest known

estimate for radars of a specific configuration to the current contract end price for radars of the same configuration acquired in the same time frame. This has been done in Table E.63.

It is important to remember while analyzing this data that it is not known what was included in the system for which the first two estimates were generated. Also, the amounts of the estimates are in the fiscal year dollars indicated while the contract prices are in the calendar year dollars of the contract; and the estimates were not necessarily developed for the same ship classes on which they were finally installed.

The fact that the estimates vary from the contract cost by between 13.8 and 34 percent would appear to indicate poor quality in estimating for this sytem. However, in passing judgement on the estimating capabilities, it must be remembered that we only have a poor sample of the estimates generated still in the record; cost growth was very nominal; three different versions are actually included within the general AN/SPS-40 configuration; and recurrent shifting of responsibility for cognizance of the estimates had negative effects on the estimating process.

TABLE E.63

COMPARISON OF CONTRACT COSTS AND ESTIMATES FOR THE AN/SPS-40 RADARS

Configuration	Estimate	Year of Estimate	Fiscal Year	Current Unit Cost	Year of Contract	Variance in Contract Price & Estimate
AN/SPS-40	$149,545[1]	1963	--	$187,190[2]	1963	26%
AN/SPS-40A	$212,000[3]	1965	66	$167,000[4]	1965	26.9%
AN/SPS-40B	$160,000[5]	1967	69	$214,760[6]	1969	34%
AN/SPS-40B	$528,000[7]	1975	76	$455,300[8]	1976	13.8%

1. For LPD, FF (DE 1052), and LPH ship classes
2. For FF, DD or DDG, LPD, and LPH ship classes
3. For FF ship class
4. For AGC, LHA, CGN (DLGN) and DX/DXG ship classes
5. For LCC and LHA ship classes
6. For DDG, DD 963, AOE and LX ship classes
7. For PCG ship class
8. For PCG and CGN 41 ship classes

*   *   *   *

The following is a summation of the cost estimating process for the AN/SPS-40 Radar.

- Staffing and Organizational Structure -- there was none for the cost estimates of the AN/SPS-40 Radars in the POM/budget process.

- Data Banks -- what data could be found were in NAVSEA 01G files and NAVSEA 02 procurement contracts. Fragmentation of cost data throughout ship files, general AN/SPS-40 files, and contract files make data gathering difficult and time-consuming.

- Return Costs -- no cost data was found other than contract prices in NAVSEA 02 contracts.

- Escalation and Inflation Prediction -- these predictions currently are functions of NAVSEA 01G. In prior years, these predictions were made by the technical organization whose predictions presumably were based on general knowledge of conditions and inputs from contractors.

- Quality versus Technical Descriptions -- the AN/SPS-40 and the A and B modifications have been operational radars for well over 20 years and as a result excellent technical material exists. However, cost estimates for this radar are not generated by reference to engineering methodology.

- Estimating Response Time -- could not be determined but with the contract history available an estimate could be provided within one or two days.

- Review Procedures -- review and validation of cost estimates for the AN/SPS-40 (all versions) is presently the function of NAVSEA 01G.

- Technical Complexity of Estimates -- the AN/SPS-40 (all versions) is not a very sophisticated radar when compared to the latest "track while scan" types. The very few design changes made in the past few years would make for accurate engineering type cost estimates if such were desired. Cost estimating for the AN/SPS-40 radars is unsophisticated as the estimates are simply the result of marking-up the latest contract cost for the effects of inflation.

3. THE 5-INCH 54 CALIBER MK 45 LIGHTWEIGHT GUN MOUNT (5" LWG) WAS THE FIRST NEW MAJOR SHIPBOARD GUN MOUNT DEVELOPED FOR THE NAVY SINCE THE 1950'S

The 5"/54 Caliber Lightweight Gun (LWG) Mount MK 45 Mod 0 was developed in response to the requirement set forth in Specific Operational Requirement (SOR) 1204R2 in March 1963 and was the first completely new major shipboard gun mount developed for the Navy since the 1950's. A development contract was undertaken by FMC Corporation/Northern Ordnance Division in April 1964. It was delivered to the Navy for testing in June 1967 and approved for service use by the Chief of Naval Operations (CNO), in July 1970. Three production contracts have been awarded to Northern Ordnance Inc. and one to General Electric for a total of 96 mounts.

The 5" LWG is a fully automatic, lightweight, shielded, single barrel weapon capable of firing 5" projectiles at 20 rounds per minute. It was developed to have the highest possible mission capability, fully automatic operation, all-weather capability, reduced space and manning requirements, low life cycle costs, and maximum safety for crew and ship. Its capabilities extend to defense against air threats; small, fast, highly maneuverable, surface targets; and provision for extremely accurate gunfire support for ground forces.

(1) <u>Although The 5"/54 MK 45 LWG Requirement Dates From 1963, The Earliest Estimate Still On File Is Dated June 7, 1967</u>

The earliest estimates still on file for the 5" LWG are dated July 13, 1967 and were found in the SEA 01G program year files for FY 69. These estimates were lump sum figures for the 5" LWG's provided by NAVORD in response to OP-030/joc Memo 0125-67 of June 7, 1967. They indicated the unit cost was expected to be \$1,680,000 for both the DDG/DXG and DE/DX classes of ships.

The second estimate was to provide for installation on the CGN 38 (was DLGN) class of ships. This estimate, with two others was found in a NAVORD Planning Directive in SEA 01G's CGN 38 files and was dated May 1970. (Table E.64 is a copy of the estimates in the Planning Directive). Although the original estimate dated April 1968 in the Planning Directive is a lump sum figure, the May 1970 estimates are broken down into specific categories which might serve as the initial points in the track of the cost history. The cost factors responsible for the difference (-16 percent) between the original (April 1968) and following (May 1970) estimates are not addressed in the Planning Directive nor can they be found in SEA 01G files.

TABLE E.64

PLANNING DIRECTIVE ESTIMATES FOR 5" LWG
(Dollars in Thousands)

	Orig. Cost Estimate April 1968 (2 Mounts)	SCA Estimate May 1970 (2 Mounts)
Mount		$2,741
Hoist		280
Technical Documentation		87
I&C/O Spares		6
Field Service Engineering		42
Systems Engineering		25
Growth		20
Specification Support Equip.		29*
Ship Qualification Trials		25
TOTAL	$3,872	$3,255

*Will not be needed if Newport News Shipbuilding and Dry Dock Company gets contract (now building CGN 36 and 37).

TABLE E.65

1968 NAVORD COST ESTIMATES FOR THE 5" LWG
December 6, 1968 (Dollars in Thousands)

	First Estimate	Second Estimate
CGN (DLGN) FY 68	1,974 (1)	1,974 (1)
LHA FY 69	1,680 (2)	1,740 (2)
DX FY 70 (DD 963)	1,611 (3)	1,520 (3)
DXGN FY 70	1,611 (3)	1,520 (3)
LHA FY 70	1,490 (4)	1,368 (4)
DXG FY 71	1,518 (5)	1,490 (5)

(1) for 5 LWG's with hoist
(2) for 3 LWG's without hoist
(3) for 32 LWG's with hoist
(4) for 32 LWG's without hoist
(5) The NAVORD cost estimate did not state whether this included hoist.

The next series of estimates was found in a NAVORD Office Memo of December 6, 1968 forwarded to OPNAV 03D. This memo provides the estimates listed in Table E.65 for gun mounts with and without hoists. It also includes extensive information explaining differences and the basis for the various aspects of the estimates. Specifically, it states:

> "The variations in price are the result of different procurement lot sizes and the configuration with or without hoist... [these estimates include] funding for spare parts, field engineering services, an allowance for specification changes, and documentation. This amounts to approximately $200,000 per mount."

Further it indicates the unit price would decrease from $1,520, 000 to $1,460,000 (-4 percent) if the number of mounts acquired by the direct buy was increased from 32 to 80.

The memo lists the following reasons for the differing cost estimates:

- Some ships require a lower hoist while other ships do not.
- The price of the gun varies with the quantity procured.

  > "As the shipbuilding program changes and the required number of gun mounts is varied, the cost will vary also."

- "The conflict between the 'program' approach, and the 'budget' approach causes price differences. If the quantities required for the DX Program of say 40 ships in priced, the result will certainly be different from that obtained for the LHA Program of say eight

ships. The cost based on quantity will be still different if the FY budget submission is considered where procurements are based on the number of DX, DXGN, DLGN, and LHA ship in a particular FY program as approved by Congress."

Finally, this memo indicates that the initial direct buy from Northern Ordnance was necessary for the first contract in order to meet ship delivery schedules. And, "these prices are expected to be somewhat higher than prices that can be obtained after the procurement data package is available and the lead times are compatible."

The fourth set of estimates still in the record is contained in a NAVORD memorandum dated January 8, 1969, discussing procurement plans for the 5" LWG. The memorandum, ORD 083/76: WRJ, indicates the intention to acquire 195 mounts over eight fiscal years at a rate of "31 mounts in FY 70 and either 24 (low rate) or 36 (high rate) in subsequent years until a total of 195 mounts had been procured." However, no information was available which stated which classes of ships these would be acquired for. The estimated average unit costs are:

FY 70 (31 mounts)	$1,522,000
FY 70-77 (195 mounts at low rate)	1,509,000
FY 70-77 (195 mounts at high rate)	1,404,000

The estimates included the costs of hoists and support costs for documentation, spares, etc.

On January 15, 1970, ORD 08 forwarded an estimate by memo ORD 08111/430: JDM to ORD 01 for five ships of the DD 963 class. Table E.66 contains this estimate.

TABLE E.66

1970 NAVORD ESTIMATES FOR 5" LWG
(Dollars in Thousands)

	01-15-70
Hardware (mount only)	$1,469
Technical Documentation	87
Test and Checkout of Systems	25
Systems Engineering	25
Ships Qualification Trials	5
Field Services Engineering	40
Travel and Per Diem	10
TOTAL	$1,661

(2) The Most Recent Estimates Come From The NAVSEA 01G And NAVSEA 06 Offices, But Do Not Allow For A Consistent Track Of The Cost History

The earliest existing estimate by SEA 01G is dated March 6, 1973 for the DD 963 ship class application, while the latest is dated November 21, 1975 for the DDG 47 applications. The estimates (see Table E.67) are broken down into various categories and provide a more consistent estimating history than was available in earlier periods. There was a quantum increase of $1,000,000 - $2,037,000 from a range of $1,178,000 - $2,730,000 in FY 75 dollars, to a range of $3,215,000 - $3,739,000 in FY 77 and 78 dollars.

TABLE E.67

NAVSEA 01G ESTIMATES FOR THE 5" LWG
(Dollars in Thousands)

	DD 963				CGN (DLGN)38	DDG 47	
Fiscal Year ------	1973	1974	1975	1977	1976	1978	1975
Date of Estimate ------	3/73	3/73	3/73	9/75	3/75	11/75	11/75
Hardware	1,137	1,157	1,178	3,215	3,082	3,739	2,730
GFE	186	199	213	321	308	-	-
Test Equipment	12	13	14	49	46	41	30
Tech. Data Doc.	62	66	71	94	90	79	58
I&C Spares	29	31	33	53	50	75	55
Contract Fld. Engr. Serv.	-	-	-	-	-	34	25
Govt. Fld. Engr. Serv.	27	29	31	48	45	43	31
Design Engr. Changes	157	168	180	94	90	188	137
System Engr. Changes	20	22	24	-	-	-	-
Total	1,630	1,685	1,744	3,874	3,711	4,199	3,066

The estimates generated in CY 1973 for FY 73-75 and those generated in CY 1975 for FY 75-78, respectively, appear consistent in the amounts of increase between Fiscal Years. The records do not however, provide an explanation for the 76 percent increase in the FY 75 estimates between those made in November 1975 and March 1973 other than the cost estimator's attempt to include a more realistic provision for experienced and projected escalation.

The only estimate, Table E.68 from the present project engineer's office still available is dated February 25, 1976 and is calculated in FY 77 dollars. The estimate was broken down as indicated below:

TABLE E.68

FY 1977 PROJECT OFFICE ESTIMATES

Hardware	$2,266,400
Shipping Fixtures	10,000
I & C Spares and Equipment	45,000
Test Equipment	25,000
Initial Spares/Supply Support	100,000
Oscillating Assembly Proofing	5,000
New Installation	100,000
Total	$2,551,400

The estimate document does not indicate what class of ships the estimate was intended for, although it indicated an expected unit buy of 14 gun mounts.

No tangible cost estimating history for the 5" LWG can be developed due to the lack of existing documentation and apparent lack of concern and effort exerted on estimating for the 5" LWG mounts by the cognizant offices in the Navy. While various estimates are available, supporting documentation defining causes for increases in the estimates and reasons for differences in the estimates in the same fiscal year were lacking in all but one case. This prevents deter-

mination of the reasons for increases, of the assumptions made in developing the estimates and of specific differences between two systems that appear on the surface to be the same. The sporadic timing and existence of estimates generated by several offices indicates an absence of a coordinated and well-managed cost estimating effort which precludes the possibility of developing a consistent track of the 5" LWG's cost estimating history for any period longer than three years.

(3) <u>The Level Of The Actual Unit Cost For The 5"/54 LWG MK 45 Has Fluctuated From An Initial High To Its Most Recent Level At 21 Percent Less Than The Initial Cost</u>

The initial major production contract was awarded in 1968 to Northern Ordnance, Inc. for twenty-five 5" LWG's to be installed on the LHA, DLGN 36 and DD 963 ship classes. The contract was a cost plus incentive fee contract with a target price of $49,869,600 and an initial unit price of $1,789,000. Table E.69 lists this and other production contracts. The major cost driver over the course of the contract resulted from a four month strike at Northern Ordnance adding $4,200,000 on to the cost of the contract. The other two major cost drivers in this contract were for $1,800,000 each. One was due to low initial estimates forwarded by Northern Ordnance to the Navy on production tooling and special test equipment. The second was due

to increased material costs subsequent to award of the contract. These cost increases resulted in an average unit cost increase of $312,000 to a final unit cost of $2,097,000.

TABLE E.69

CONTRACTS FOR 5" LWG

Year of Contract	Contractor	Quantity	Initial Unit Cost	Current Unit Cost
1968	Northern Ordnance, Inc.	25	$1,789,000	$2,097,000
1971	General Electric	54	$ 852,000	$ 976,655
1972	Northern Ordnance, Inc.	7	$1,300,000	$1,300,000
1975	Northern Ordnance, Inc.	14*	$1,655,986	$1,697,736

* Reduced to 10 units after contract award.

The second major production contract was awarded in 1971 to General Electric following open competition. This contract was for fifty-four 5" LWG's to be installed on the DD 963 ship class at a unit cost of $852,000 and total cost of $46,008,000. However, this price did not include hoists and other components which were contracted for from Northern Ordnance and furnished as GFM. The contract was a fixed price contract with procurement scheduled in four lots, one each for Fiscal Years 71-74. The first lot (FY 71) was for 12 gun mounts while each of the other three lots was for 14 gun mounts. By November

3, 1976 the total cost for this contract had increased to $52,739,343 (14 percent) increasing the average unit cost to $976,655. Of the 18 contract modifications affecting the price of the contract, fifteen were GFM related, three due to design modifications, and three to unit price increases. The GFM changes accounted for 85.8 percent ($5.73M) of the increase in dollar value of the contract.

The third major production contract was with Northern Ordnance in 1972 for seven gun mounts at a total price of $10.65M ($1.5M per unit). These gun mounts were acquired for installation on ships of the CGN 38 and DD 963 classes. Northern Ordnance was awarded this contract through competitive bidding and has since satisfactorily completed the contract.

The last major production contract was awarded in November 1975 to Northern Ordnance after selection through comptitive bids. It was a fixed price contract for 14 mounts with a total price of $23,184,000, a unit price of $1,656,000 with an option to acquire two more at a unit cost of $2,208,000. However, in August 1976 the total price was decreased by $2,622,000 to $20,562,000 pursuant to contract price adjustments agreed to by the Government and Northern Ordnance because of the deletion of four mounts for a new total of ten mounts. The only other change was a reduction in the contract

price for additional GFM supplied to the contractor. These reductions decreased the current average unit cost to $1,700,000. Eight of the ten systems were acquired for Foriegn Military Sales (Iran) while two systems are for installation on the CGN 41 and 42.

(4) Neither GFM Nor The 5"/54 LWG MK 45 Have Been Major Cost Drivers

Although GFM was the major cost driver in the second contract, charges attributed to GFM in the fourth contract caused a net reduction in the total contract cost. In consideration of these mixed results and their magnitude, GFM does not appear to merit special concern as a cost driver for the 5" LWG.

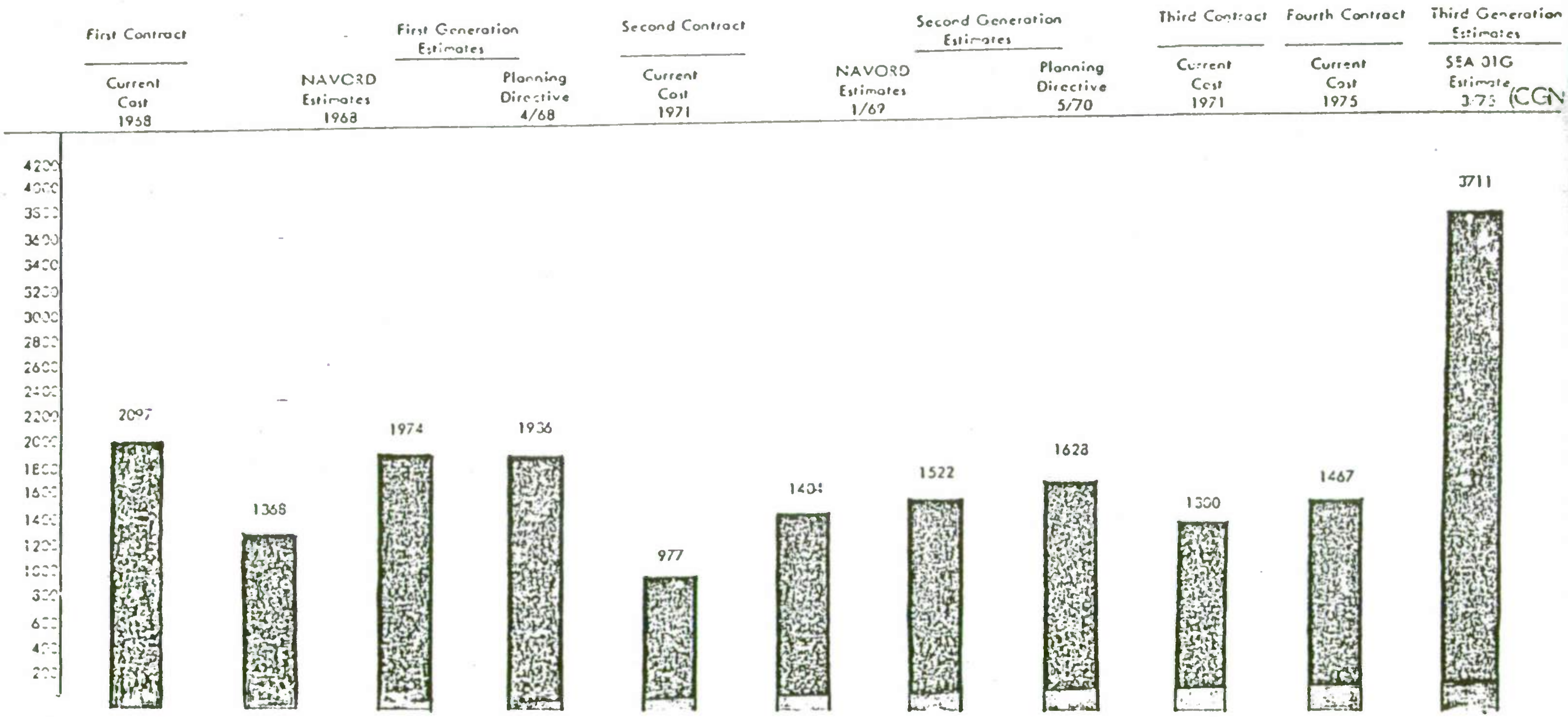
In regards to the 5" LWG being a cost driver in ship acquisitions, there has been an actual cost reduction in spite of inflation over the course of the four contracts. The nominal cost decrease is even greater than these figures portray as the system has been modified and increased capability has been added since its initial production. Thus, it appears that the 5" LWG has shown improved cost performance and the Government has been successful in keeping a lid on the cost increases.

(5) The Quality Of Estimates For The 5"/54 LWG MK 45 Appears To Have Been Very Low Throughout Its History

Figure E.14 relates estimates to anticipated end prices per unit. While the estimates are not exactly comparable since they apply to different ship types, etc., they have been consistently low until recently. The later SEA 01G estimates appear to be high in that they are from 50 percent to 100 percent higher than the anticipated end cost of the mounts being procured under the contract awarded in 1976. These increases are attributed by SEA 01G to anticipated inflationary factors and lack of compeition as it is anticipated that GE will no longer be interested and 5" LWG's will be procured sole source from Northern Ordnance.

FIGURE E.14

MK 45 LWG CURRENT CONTRACT COST AND RANGE OF ESTIMATES
(000's of Dollars)



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The following is a summation of the cost estimating process for 5" LWG.

- Staffing and Organizational Structure -- although many different offices have promulgated estimates for the lightweight gun, the efforts do not appear to have been coordinated or well-managed.

- Data Banks -- only limited data for the 5" LWG is still in existence with the most complete cost data available being that found in NAVSEA 02's contract files. No actual cost data banks for the LWG were available.

- Return Cost -- the only return cost data available are the contract costs found in NAVSEA 02's contract files.

- Escalation and Inflation Predictions -- NAVSEA 01G has general cognizance of this function and promulgates its figures for use by all offices involved in estimating.

- Quality versus Technical Description -- the 5" LWG has a stable design with complete and accurate technical descriptions. Therefore, the risk factor in the estimates should be low and the quality of the estimates should be very high given this situation.

- Estimating Response Time -- since the estimates were the result of marking up the latest contract costs for the effects of inflation, it appears the amount of time necessary for the generation of estimates would be quite short.

- Technical Complexity of the Estimates -- as the estimates appear to be percentage mark-ups of the latest contract costs, the technical complexity of the estimates appears to be very low.

4. THE MK 86 GFCS HAS EXPERIENCED NUMEROUS INCREASES OF ITS CAPABILITIES, ACTUALLY EVOLVING INTO DIFFERENT SYSTEMS WITH THE SAME CENTRAL COMPONENTS

The Specific Operational Requirement (SOR) for the MK 86 Gun Fire Control System (GFCS) was issued in February 1963 as a result of an operational requirement issued by CNO in August 1961. The new GFCS was designed for surface to surface gunfire in support of amphibious operations.

In February 1964 a contract was awarded Lockheed Electronics Co. for the design and manufacture of two prototype MK 86 GFCS. The first system was delivered in May 1966 and accepted by the Naval Ordnance Systems Command. This system was subsequently installed on the USS BARRY (DD933) for a Concurrent Evaluation, CNO Project C/A 45. Due to technical problems this evaluation was never completed.

In November 1966, CNO issued a revision to the SOR adding Anti Aircraft (AA) and Missile Continuous Wave Illumination (CWI) capability requirements for the MK 86 GFCS. In July 1967 Lockheed was awarded contracts for improvement programs to further develop the MK 86 and also to provide an AA and CWI capability. One of the original two MK 86's, modified in accordance with the July 1967 contract by Lockheed, was installed on the USS NORTON SOUND (AVM 1) for technical evaluation in January 1969. During the evaluation, the MK 86 demonstrated a capability to meet the desired per-

formance requirements.

The MK 86 GFCS Mod 3 controls two guns primarily on the CGN 36 class (formerly the DLGN 36); the Mod 4 controls three guns on the LHA class; and the Mod 5 controls two guns and provides missile guidance for the CGN 38 class ships (formerly the DLGN 38).

(1) <u>There Is No Uniform Cost History Available. Seven Different Offices In The Navy Have Contributed Cost Estimates For The MK 86 GFCS Over An Eight Year Period</u>

The earliest cost estimate still in the record was promulgated January 28, 1964 by the NAVORD CB-1 Office (presently in SEA 06) for the DDG-2 ship class. It was for SCN appropriations with a figure of $1,400,000 for one MK 86 GFCS for surface gunfire only. The next estimates were found in a NAVORD 931 Memorandum of June 13, 1967 which was based on an OP-030/joc Memo 0125-67 of June 9, 1967. They were calculated in FY 69 dollars and indicated a MK 86 Mod 2 GFCS for the DDG/DXG classes of ships was expected to cost $2,297,000 while a MK 86 Mod 1 GFCS for the DE/DX-DD 963 ship classes was estimated to cost $2,250,000. These estimates were found in SEA 01G's Program Year Files and did not break out the component costs, but only conveyed a lump sum estimate. The Mod 1, as well as the Mod 0 and Mod 2 were never developed as systems but were used as operational development equipment.

An early estimate on record (Table E.70) dated January 15, 1970 was forwarded in a memorandum by ORD 08 to ORD 01. It was calculated for the DD 963 ship class and is the first breakdown of the costs into various categories, although the specific mod number of the GFCS was not indicated. The other estimates are for specific mods and no explanation of the differences in basic hardware predictions has been found. The estimates for items other than basic hardware reveal a typical pattern. First, the item coverage is not consistent. Second, the estimates for individual items vary widely. It is rare that reasons for the variations can be found in any sort of documentation.

The estimates in Table E.71 were found in the DLGN 38 Ship File in the SEA 01G office. They were part of a Planning Directive promulgated by ORD 01214 for the DLGN 38 ship class on May 28, 1970. They do not indicate which of the MK 86 configurations they apply to, precluding their further use for an historical analysis. However, assuming they are all estimates for the Mod 5, they demonstrate, but do not explain, a cost growth of 104 percent over this two year period. The cost growth could have resulted from the many design modifications associated with the missile guidance requirement.

ORD 012C promulgated in a letter, serial number 0640 on February 9, 1970, an estimate for the DLGN 38 ship class application of $4,100,000

TABLE E.70

NAVORD ESTIMATES FOR THE MK 86 GFCS
(Dollars in Thousands)

Ship Classes	DD 963			FFG (PF)
NAVORD Code	ORD-08	ORD-55142	ORD-55142	ORD-051.1
Fiscal Year	FY 70		FY 73	FY 73
Est. Date	01/15/70	1/30/71	12/10/71	12/14/72
Mod Number		Mod 5	Mod 3	Mod 5
Hardware	3,630	3,800	3,375	4,500
Growth	15			
Tech. Doc.	192	10		800
Test Checkout	25		80	20
Sup. Eng.	15	100		500
Fld. Serv. Eng.	25	100	61	100
Travel & Per Diem	25			
I&C Spares		50		600
SQT Costs		30		30
Initial Spares			150	600
Design Eng. Change			200	
Develop Costs				1,000
Total	3,977	4,090	3,866	8,150

TABLE E. 71

PLANNING DIRECTIVE ESTIMATE FOR THE MK 86 GFCS
(Dollars in Thousands)

	SCA Estimate May 1970	Latest Estimate May 1970
Basic System	2,508	2,990
Technical Manuals	130	130
Technical Data	35	35
Engineering Liaison Services	25	25
Source Control Drawings	30	30
I & C Spares	25	25
Computer	565	565
Field Engineering Services	25	25
Spares Provisioning	10	10
Special Test Equipment	150	150
Specification Changes	150	150
Production Support	25	25
Generators -- MK 56	2	2
Dummy Director and Error Recorder	25	25
Input/Output Console MK 77	20	20
Ready Spares Cabinet	25	25
Cable Connectors	15	15
CWI	435	435
Total	4,200	4,682

NOTE: Original cost estimate of April 1968 was $2,300,000.

for a MK 86 Mod 1. Fiscal year information and cost breakdowns were not included with this estimate. It should be noted that the Mod 5 was installed on the DLGN 38 (now CGN 38).

The next two existing NAVORD estimates, were for systems to be installed on ships of the DD 963 class. The first, for a MK 86 Mod 5 GFCS, was dated November 30, 1971 and did not include any fiscal year designation, while the second for a MK 86 Mod 3 GFCS was dated December 10, 1971 and was calculated in FY 73 dollars (See Table E.70).

It is interesting to note that of all the estimates available on the MK 86 GFCS, only the above two were classified as to quality. These were listed as being "F" class, a "ball park" estimate.

In sum, it is noted that there is a significant lack of cost information for this system. Moreover, the offices (seven) promulgating estimates for the MK 86 demonstrate an apparent lack of effective management in the cost estimating process.

Of final note to this section is a letter from the Commander, NAVORD to the Chief of Naval Material dated October 23, 1970 stating:

> "A representative of the Office of Management and Budget has requested cost data on those MK 86 GFCS currently under contract. Cost data is not available at this time since the contract has not been completed."

This demonstrates the absence at that time of data banks for the GFCS and the apparent importance of contracting data in the estimating process.

(2) SEA 01G And SEA 06 Estimates Developed Primarily In 1975 - 1976 Though Well Documented, Still Contain Discrepancies

The earliest estimates still available from SEA 01G and SEA 06 (the project office for the MK 86), were dated March 1973 and October 1975, respectively. Most of the estimates by SEA 01G were dated from September to November 1975 (11 out of 17) with the ones made in November being the latest of SEA 01G's estimates on record. The estimates in the record from SEA 06 primarily were (8 out of 13) dated October 22, 1975. (See Tables E.72 and E.73).

Although the estimates from both of these offices are broken down into various categories and supporting documentation has been provided for individual estimates, there exists some points of conten-

tion which are not addressed. One point of particular interest is the unexplained variation in hardware costs between estimates of the same fiscal year from what should apparently be the same equipments. For example, the FY 77 estimates (Table E.72) for the MK 86 GFCS Mod 3 hardware varies between \$3,215,000 and \$6,110,000 while the hardware estimates (Table E.73) for a MK 86 Mod 5 GFCS vary between \$2,985,000 (FY 76) and \$6,920,000 (FY 78) in SEA 06's estimates. These differences are particularly perplexing when it is understood that the primary source of data used by both offices for these estimates has been contract and actual cost data.

Other components of the cost estimates such as Installation and Checkout (I&C) Spares, System Test and Evaluation, and Technical Data and Documentation Requirements, also constitute unexplained variations for the same system and fiscal year.

The most consistent and coordinated estimates were those generated in October 1973 by SEA 01G for the DD 963. They are uniform in content and demonstrate a consistent cost history over a three year period. However, it should be noted that subsequent estimates were the result of simply increasing the preceding year's estimate by certain inflation factors.

TABLE E.72

ESTIMATES FOR THE MK 86 GFCS SEA BIG FOR SCN APPROPRIATIONS

(All Figures in 000's of Dollars)

SHIP CLASS FY/CY MOD. NUMBER	DLGN 38 FY 74/04-11-73 3	DLGN 38 FY 77/10-23-73 5	DLGN 38 FY 74/23-06-73 0	DLGN 41 FY 74/12-03-73 0	LX 1 FY 77/09-03-73 2	CSGN FY 77/09-12-73 2	CSGN FY 77/09-23-73 2	DDG 2/15 FY 77/10-23-73 2	DD 963 3/73 FY 73	DD 963 3/73 FY 74 0	DD 963 3/73 FY 75	DD 963 FY 77/09-04-73 2	DD 963 FY 77/10-23-33 2	DDG 47 FY 73/11-31-73 0	DDG 47 FY 77/10-23-73 0	DDG 47/CSGN FY 76/10-23-73 0	DDG 47 FY 78/11-31-73 0
Hardware	3300	4193	2002	3129	3113	3033	3235	4093	1137	1137	1175	3215	3093	2517	2400	2494	3738
GFE	1277	1176	200	313		602	354	1063	103	179	312	301	420	313	334	304	
Software	89	97				130	300	76					97		90	104	
Proj. Management	30	57			70	143	57	57					57		57	63	
I & C Spares	330	337	80	33	411	374	341	316	29	31	33	53	443	53	376	408	73
Design Engr. Changes	330	337	90		411	374	341	313	157	160	180	94	443	137	373	408	180
Sys. Test & Eval.		57			70	130	57	57					57		57	63	
Test Equip.	70		44	80	193	70			13	13	16	49		30			41
Contr. Fld. Engr. Serv.	140	73	43		73	300	73	73	27	29	31		73	23	73	31	34
Govt. Fld. Engr. Serv.	271	60		31	60	300	60	60				40	60	31	60	63	43
Tech. Data Doc.	80	34	90	134	373	153	34	34	63	66	73	94	34	80	34	37	79
ILS Mgt.	30	57			70	140	57	57					57		57	63	
QA & RMA	80	43			93	106	46	43					46		43	47	
Configuration Mgt.	30	33			33		23	23					23		33	36	
CRDALTS	80	106			30		104	131					174		100	117	
Sys. Engr.		314							30	33	34			300			
EQT		130												44			
Initial Spares																	
Total	8767	7763	2711	3560	8397	8402	6130	6877	1626	1665	1744	3074	6225	3310	5130	8539	4199

TABLE E.73

ESTIMATES ON THE MK 86 GFCS PERFORMED BY SEA 65322 FOR SCN AND OPN APPROPRIATIONS

(All Figures in 000's of Dollars)

SHIP CLASS FY/CY MOD. NUMBER	CG 26 FY 76/01-19-76 3	CG 25 FY 76/01-19-76 5	DDG 2/15 FY 76/10-22-75 5	DDG 47 FY 78/11-04-75 5	DD 2/15 FY 77/10-22-75 5	CSG(N) FY 76/10-22-75 2	CSG(N) FY 77/10-22-75 3	DD 963 FY 76/10-22-75 2	DD 962 FY 77/10-22-75 2	DD 983 FY 77/12-16-75 0	CGN 38 FY 76/10-22-75 5	CGN 38 FY 77/10-22-75 5	FF 1052 FY 77/12-14-75 5
Hardware	2898	2985	3128	6920	2547	1868	2117	3028	3430	2893	3204	3630	4380
GFE	439	494	398		448	308	347	427	482	436	483	1044	1242
ORDALTS	89	89	160		181	95	108	155	175	25	164	186	33
Software	86	86	87		96	87	96	89	97		89	97	34
Proj. Mgt.	50	50	50	100	57	50	57	50	57	80	50	57	15
I & C Spares	336	368	311	230	353	185	310	301	341	30	319	341	554
Design Engr. Chng.	336	368	311	400	352	185	210	301	341	200	219	341	100
Sys. Test & Eval.	50	50	50	30	57	50	57	50	57	25	50	57	21
Contr. Fld. Engr. Serv.	44	44	47	50	75	67	75	67	75		67	75	219
Govt. Fld. Engr. Serv.	53	52	52	100	60	52	60	53	60	20	52	60	21
Tech Data Doc.	21	21	30	100	34	30	34	30	34	56	30	34	119
ILS Mgt.	50	50	50	100	57	50	57	50	57	125	50	57	20
QA & RMA	43	43	40	50	45	40	45	43	48		42	48	17
Config. Mgt.	22	22	44	100	50	44	50	44	50		44	50	9
Sys. Engr.										50			227
SQT													125
Initial Spares				80						100			
Total	4568	4954	4779	8180	5413	3113	3523	4687	5305	3960	4964	6117	7136

Besides the paucity of supporting documentation for the MK 86 GFCS cost estimates, the format inconsistency, variations in estimate systems, and the apparently uncoordinated efforts in generating these estimates are not conducive to the development of specific conclusions. It is apparent then that the cost estimating effort is deficient as evidenced by the absence of documentation.

(3) Although There Have Been Three Production Contracts, The MK 86 GFCS Has Not Been Opened To Competitive Bidding

The first production contract for the MK 86 GFCS was awarded to Lockheed Electronics Co. in 1970 for sixteen systems for DD 963 class ships, LHA's 1-3, and the CGN 37, at an average unit price of $3,774,313. As this was the first production contract, it was a Cost Plus Incentive Fee (CPIF), contract target and ceiling costs were negotiated. Lockheed was to receive incentive payments for any cost savings realized.

Since the first contract was definitized in 1971, there have been twenty-three modifications affecting the target or ceiling prices. The current ceiling price is approximately $72,078,916. The primary cause of price increases has been due to design and engineering

changes. However, a group of miscelloneous cost drivers including technical monual changes, increased supplies of certoin materiol, specific tests, etc., is the couse of the largest number of chonges (11 out of the total 23) and for 65 percent of the volue of the chonges. The cost difference resulting from the GFM changes netted out to on octuol reduction of obout $225,000. The total value of oll the chonges is approximately $6.5 million or 11 percent of the original target price.

The second contract (1973), olso with Lockheed Electronics, included 11 MK 86 Mod 3 and 4 GFCS's and options for 14 MK 86 Mod 3 GFCS's for the DD 963 closs ond 3 MK 86 Mod 5's for the CGN 38 class. This wos a CPIF contract with o target price of $27.5 million, ceiling price of $33 million and unit hardware price of $2,628,909. (These figures do not include the options.) By June 1975, oll of the options had been exercised, increosing the target and ceiling prices to $74,181,591 and $82,792,500 respectively.

Since contract oword there hove been fifteen controct modificotions, six of which affected the cost. Two were mentioned obove os enactment of the options while four were due to design modifications or equipment substitution. The net result of these four modifications has been o $329,702 (1.2 percent) increose of the torget price ond

$350,584 (1.1 percent) increase of the ceiling price.

A third CPIF contract was negotiated with Lockheed in 1975 for the Iranian DD's. The contract price for four systems totalled $15,995,000 or a unit price of $3,998,750. Since the Foreign Military Sales (FMS) requirements are different, the above unit cost should not be used for comparison.

Although the contracting office would prefer to open procurement of this sytem to competitive bids, the lack of procurement planning forces them to rely on Lockheed as the sole source. If another firm were to undertake production of the MK 86, it would require several months of lead time for tooling-up following award of the contract.

TABLE E.74

PRODUCTION CONTRACTS FOR THE MK 86 GFCS

Year	Quantity	Approximate Average Hardware Price*
1970	16	$3,774,313
1973	11 (28)**	$2,628,909*
1975	4	$3,998,750

* Target price at time of contracting
** The option for a total buy of 28 was exercised

(4) <u>Historical Data Is Incomplete For The MK 86 GFCS And Indicates A Lack Of Estimating Effort And Managerial Direction</u>

The scarcity of recorded data on the cost estimating history of the MK 86 GFCS prior to December 1973 for the CGN 41 has precluded a detailed analysis of this system and allows only a cursory review of the process which could be misleading.

From what is available, it appears that the in-house estimating effort was limited, primarily relied on and still relies on contract data and mark-ups for escalation. Data banks for cost estimating information do not appear to exist for the MK 86 GFCS.

The cost estimating effort was not well coordinated and was ill-defined with many offices promulgating estimates of varying quality and format without supportive documentation. These conditions appear to have been remedied to some extent more recently with SEA 01G serving as the coordinator of the estimates, although questions persist regarding the variations in and content of the latest estimates.

* * * * *

The following is a summation of the cost estimating process for the MK 86 Gun Fire Control System (GFCS).

- Staffing and Organizational Structure -- the SEA 06 project office is not presently organized or staffed for cost estimating the MK 86 GFCS. As the GFCS has been in production since 1970, contract prices provide cost data to SEA 06. In general, cost estimating for the MK 86 GFCS is not considered an important function in NAVSEA 06.

- Data Banks -- no actual cost data banks were found although cost information is scattered throughout SPD's, SEA 01G files and contracts in SEA 02. The most complete cost estimate information can be found in the SEA 01G files, however, no back-up information exists as to how the estimates were derived, i.e., based on contracts, contractor's advice, past engineering or parametric studies. Nor do the SEA 01G estimates break the estimate down to include the consituent line items of the total cost.

- Return Cost -- the only return cost information was found in the SEA 02 files and contracts.

- Escalation and Inflation Predictions -- SEA 01G now has cognizance of this function but did not when this system first came into being.

- Quality vs. Technical Description -- the MK 86 GFCS has at this time a stable design with complete and accurate technical baselines. The risk factor in cost estimating should be low and quality of estimates high.

- Estimating Response Time -- a procedure which only reviews the latest contracts and adds inflation factors would probably result in a short response time.

- Review Procedures -- there was no evidence of review procedures.

- Technical Complexity of the Estimates -- the technical complexity of the estimates is very low since an estimating technique which consists only of updating contract cost data requires little else.

5. THE AN/SQS-53 SONAR IS A SECOND GENERATION SONAR

The AN/SQS-53 Sonar is a modified AN/SQS-26CX, which has been installed on Navy surface ships since the early 1960's. It's purpose is to provide detection, classification, and localization of underwater targets.

The AN/SQS-53 Sonar, first defined in 1968, has been installed on DD 963 class ships and the AN/SQS-53A on the CGN 38, 39, 40 and 41 (were DLG's). The CGN 42 and the DDG 47 class ships are also to receive AN/SQS-53A.

(1) The AN/SQS-53 Sonar Did Not Follow The Normal NAVSEA System/Equipment Development

The AN/SQS-26CX Sonar, developed in the early 1960's to interface with the Underwater Battery Fire Control System (UBFCS) MK 114 (analog) was scheduled for installation on the DD 963 and CGN 38 class ships which are equipped with the UBFCS MK 116 (digital) and Command and Control Systems (digital). During the several conferences in 1967 between the Navy, General Electric (Sonar) and Librascope (UBFCS) on sensor/weapons integration it was decided that modifying the AN/SQS-26CX Sonar to provide digital outputs was preferable to doing the necessary data conversions in separate converters. Contract N00024-68-C-1160 was awarded in

March 1968 by NAVSEA to the General Electric Co. to define the flow of digital data between the UBFCS MK 116 and the AN/SQS-26CX and to provide modifications necessary for digital interfaces. This contract was extended in October 1968 and resulted in an advanced development model, which was successfully tested with a digital AN/USQ-20(V) computer. The extensive changes to the many cabinets of the AN/SQS-26CX Sonar and the addition of a new cabinet necessitated a change of nomenclature to the AN/SQS-53 and 53A in September 1971.

The cost of the AN/SQS-53 Sonar is included in the DD 963 shipbuilding contract between the Navy and Litton. Litton contracted directly with General Electric to package the advanced development model to meet Navy specifications.

(2) The First Two AN/SQS-53A Sonars Procured As Government Furnished Material (GFM) Were Modified AN/SQS-26CX Sonars

General Electric on 23 December 1970, was awarded Contract N00024-71-C-1081 to conduct a comprehensive analysis of the effort and time required to modify two existing AN/SQS-26CX Sonars to interface with the UBFCS MK 116-1. The contract stated that "interfaces being procured were to be identical to the maximum extent

possible, to the Sonar/FC interfaces being developed for the DD 963 program."

In September 1971 General Electric was awarded a contract to modify two government furnished AN/SQS-26CX Sonars to AN/SQS-53A for installation on the CGN 38 and 39. These 26 CX Sonars, originally scheduled for ships deleted from the shipbuilding program, had been procured in January 1968 from GE at a cost of \$1,880,302 each and were subsequently modified at a cost of \$1,032,800 each. Thus, the unit cost of the modified sonars for the CGN's was as follows:

Contract N00024-68-C-1130 (Jan. '68)	\$1,880,302
Contract N00024-72-C-1064 (Sept. '71)	\$1,032,800
Total Cost	\$2,913,102

The only estimate required was for the modifications to the above sonars. The original estimate (date unknown) of \$983,000 for one modification was recorded in a handwritten memo between SEA 06 offices, dated 9/25/75. The actual cost of one modification, (Contract N00024-72-C-1064) was for \$1,032,800 or within 5 percent of the original cost estimate.

(3) <u>The Only Procurement Of The AN/SQS-53A Sonar As GFM Has Been For The CGN 40 and CGN 41</u>

Cost estimates for the CGN 40 and 41 AN/SQS-53A's were found in a handwritten memo, PMS 302-22 of 19 December 1973, in the project engineer's files which listed a number of estimates for the AN/SQS-53A made on different dates.

Hardware	$3,721,278
Engineering Services	74,440
	$3,795,718

Included in the above hardware costs are items 2, 3, and 4 as listed below. Contract N00024-73-C-1222, dated February 2, 1973 for the CGN 40 sonar lists the following items:

Item 1 - AN/SQS-53A Sonar Set (less transducers and cables 1 each)		$2,375,950
Item 2 - Transducer Elements for item 1		303,500
Item 3 - Stave Housing		16,250
Item 4 - Trunk Cables		26,300
Item 5 - Engineering Services, Domestic		(Est.) 60,000
Item 6 - Support for item 5		(Est.) 10,000
	Total	$2,792,000
Contract modifications --	Total	229,421
Actual Cost		$3,021,421

The hardware cost estimate plus engineering services ($3,795,718), when compared with the final contract cost ($3,021, 421) shows the estimate to be approximately 25 percent high.

For contract N00024-74-C-1179, dated March 4, 1974, the CGN 41 sonar shows a final cost of $3,232,250 as compared with the cost estimate of $3,795,718, a difference of approximately 18 percent.

Since the AN/SQS-53A was an AN/SQS-26CX with cabinet changes for digital transmission plus an additional cabinet already developed by Litton for the AN/SQS-53 for installation on DD 963 class ships, cost estimating the well defined AN/SQS-53A should not have been too difficult. However, the overestimate of 25 percent for the CGN 40 and 18 percent for the CGN 41 is considered excessive.

All the Navy contracts for the AN/SQS-53's with GE were sole source fixed fee, since GE was in production (DD 963).

(4) <u>Future Sonar Contracts For The CGN 42 And DDG 47 Class Ships Will Reflect Much Higher Cost</u>

PMS 389/VRH, DDG 47/7110.29 serial 05 of 10 June 1977 states:

"It came to light after the FY 78 budget submission that the AN/SQS-53A would increase (costs) almost $3,000,000. This is primarily due to the Sonar Modernization program with the additional hardware requirements and allied increases in the system engineering, documentation; ILS, etc."

Increasing costs had already been predicted by SEA 06 in Cost Estimate Documentation Summary Sheets for follow systems as indicated below.

TABLE E.75

AN/SQS-53 PROJECT OFFICE ESTIMATES

	12/18/75	12/10/76	Difference
Hardware Spares	$3,638,000	$4,960,769	+$1,322,769
Engineering Ser.	120,000	165,912	+ 45,912
Total	$3,758,000	$5,126,681	+$1,368,681

(For comparison with previous Sonar costs, only hardware and engineering services are listed.

Although the above 12/18/75 cost estimate is close to the 12/19/73 for the CGN 40 and 41 ($3,795,718) the 12/10/76 estimate indicates the upward cost trend noted in the PMS 389 letter of 10 June 1977.

(5) Comparison Of Contract Costs For The AN/SQS-53 And AN/SQS-53A Show Small Differences

The 53 and 53A sonars are physically and functionally the same and have identical interfaces between the digital MK 116-0 UBFCS for the DD 963 class and the MK 116-1 UBFCS for the CGN 38 class ships. Litton purchase order #21-02-A04002-01 of 5/18/72 was with GE for nine AN/SQS-53 sonars (first increment of 30 total) to be installed on the DD 963 class ships as contractor furnished equipment. The Navy contracts for the CGN 40 and 41 sonars, previously discussed are Government Furnished Equipment. The following is a comparison of their costs.

TABLE E.76

DD 963 AND CGN SONAR CONTRACT PRICES

	Unit Price
DD 963 (CFE)	$3,186,437
CGN 40 (GFE)	$3,021,421
CGN 41 (GFE)	$3,232,250

The small difference in costs could be attributed to GE viewing the Navy buy of two sonars as an extension of the Litton contract signed on May 18, 1972 since the requirements of Navy contracts N00024-73-C-1222 dated February 2, 1973 (Procurement Request (PR) circulated in mid 1972) and N00024-74-C-1179 dated March 4, 1974 (PR in late 1973) were no doubt known by GE. It would be logical,therefore that the Litton and Navy purchases of almost identical sonars were almost identical in cost.

* * * * *

The following is a summation of the cost estimating process for the AN/SQS-53/53A Sonars.

- Staffing and Organizational Structure -- the cost estimates were well managed.

- Data Banks -- the cost information was readily available and tracked the cost history.

- Return Costs -- copies of the contracts and the changes thereto provided good return cost information.

- Escalation and Inflation Predictions -- SEA 01G has general cognizance of these predictions and will add on the inflation factors for SCN monies.

- Quality vs. Technical Description -- the sonar has a stable design with complete and accurate descriptions and complete cost information is available. However, the quality of estimates were marginal as they were on the high side (approx. 17 percent and 25 percent.)

- Estimating Response Time -- cost data from Litton was readily available.

- Review Procedure -- acceptable.

- Technical Complexity of the Estimates -- the technical complexity was low since Litton contract update data was used.

6. THE CLOSE IN WEAPON SYSTEM (PHALANX CIWS) WAS DEVELOPED IN A COST CONSCIOUS ATMOSPHERE

The PHALANX CIWS is an automatic, self-contained unit consisting of a search and track radar, digitized fire control system, and a 20 mm Vulcan gun. The system is mounted in a single, above deck structure requiring a minimum of interface with other shipboard systems.

In its primary operational sequence, the search radar normally detects and evaluates a potential target by comparing target parameters (speed and angle of appraoch) with potential threat data stored in the fire control computer.

After the target is declared a threat, it is tracked by the radar. The system begins firing a stream of projectiles timed so that the first projectiles arrive in the vicinity of the target when the target has closed to a preselected intercept range. From that point on, the fire control computer compares the incoming target with the centroid of the stream of projectiles in the vicinity of the target and generates aiming orders to the gun to bring the stream of projectiles onto the target. Thus, the system is expected to automatically detect, track, engage, kill, and return to search.

The CIWS is a fast reaction system designed specifically to fulfill the "last ditch defense" concept against all low-flying, high speed antiship

missiles. It is designed for a quick and inexpensive installation on surface ships and requires only ship's power and coolant water for operation.

(1) The CIWS Project Has Been In Research And Development Since The Late 1960's

In 1966, the Chief of Naval Operations sought proposals from industry for a lightweight gun system capable of defending ships from attacks by antiship cruise missiles. In 1968, the General Dynamics Corporation responded with a proposal for the PHALANX. Following concept formulation and feasibility tests, the program entered the engineering development phase in December 1970. Under this effort, two prototypes were fabricated and delivered for testing.

Unlike other weapons systems being studied, the CIWS project has no procurement history. Although procurement was originally planned for an earlier period, first production runs are now planned for June 1979.

Due to the R&D status of the project, a study of cost estimating performance primarily relates to the ability of project and contractor personnel to correctly estimate the end cost of the R&D process. Beyond that, the development of a procurement price and its subsequent

use for both project and budget purposes can be traced.

It should be noted at the outset that there are several distinct phases of the Research and Development effort.

- Between 1969 and late 1973, the plan was to develop in quick succession, prototypical and operational suitability models with heavy reliance on simulation and increasingly stringent phased testing of some nine or ten early units.

- During 1973, Defense Department policy took on the form of "fly-before-buy" a concept requiring considerable change in the method of producing and testing the early CIWS units. Emphasis was placed on comprehensive testing on only a few lead-weapon units. This approach caused a complete re-appraisal of projected costs when resulted in a tripling of expected R&D end cost.

- Since late 1973, the final phase has been in effect and is showing steady progress to target cost despite testing and funding difficulties.

(2) <u>The CIWS Program Has Incurred A Delay Of Thirty Months Due To Direction Changes, Testing Problems And Congressional Modification Of Planned Expenditures</u>

The original plan for development of the CIWS subsequent to the CNO request for proposals in 1966 was as follows:

- Construction of pre-prototype unit for engineering tests.

- Construction of two prototype units for at-sea and RMA testing.

- Construction of six to nine Operational Suitability Models (OSM) for at-sea testing and to develop production procedures.

- Production of 368 units (includes 6 OSMs) between FY 73 and FY 79.

Figure E.15 , which follows, identifies the 12 milestones which were planned to successfully complete the program.. Figure E.16 shows schematically the original events versus actual events, emphasizing the program delays beginning at Event Seven -- Award Contract for the Operational Suitability Model.

The reasons for delay (as keyed on Figure E.15) beginning subsequent to the "direction change" and into the second phase of development are:

- Extended land-based testing and bad weather.

- Decision to use Prototype #2 as testing a model for life of program.

- Reprogramming action by Congress seven months after contract was ready to execute. Further delay after Congress reduced Operational Suitability Model (OSM) buy from six to option for one. Option for one exercised 1 March 1976.

- These events are functions of the Congressional holding action. The option for one OSM was exercised in March 1975 with actual delivery in November 1976

FIGURE E.15

CIWS PROGRAM EVENTS

Event	Planned	Actual	Delay Mos.	Delay Reasons
1. Award contract and start Engineering Development	December 1970	December 1970	0	
2. Complete fabrication of Engineering Development Model (pre-prototype)	May 1972	May 1972	0	
3. Complete testing of pre-prototype	September 1972	September 1972	0	
4. Complete testing of Prototype #1 and #2	December	December	0	
5. Complete At-Sea Test of Prototype #1	November 1973	March 1974	4	(1)
6. Complete RMA proofing of Prototype #2	December 1973	NA	4	(2)
7. Award contract for Operational Suitability Model (OSM) program	November 1973	June 1974	7	(3)
8. Deliver OSM #1	November 1974	November 1976	24	(4)
9. Commence At-Sea Test of OSM #1	February 1975	May 1977	27	(4)
10. Complete At-Sea Test of OSM #1	July 1975	July 1977	24	(4)
11. Award Production Contract	July 1975	October 1977	27	(5)
12. First Production Run	January 1977	June 1979	30	(6)

Reasons for Delay

(1) Extended land-based testing and bad weather.

(2) Decided to use Prototype #2 as testing model for life of program.

(3) Reprogramming action acted on by Congress seven months after contract ready to execute. Further delay after Congress reduced Operational Suitability Model (OSM) buy from six to option for one. Option for one exercised 1 March 1976.

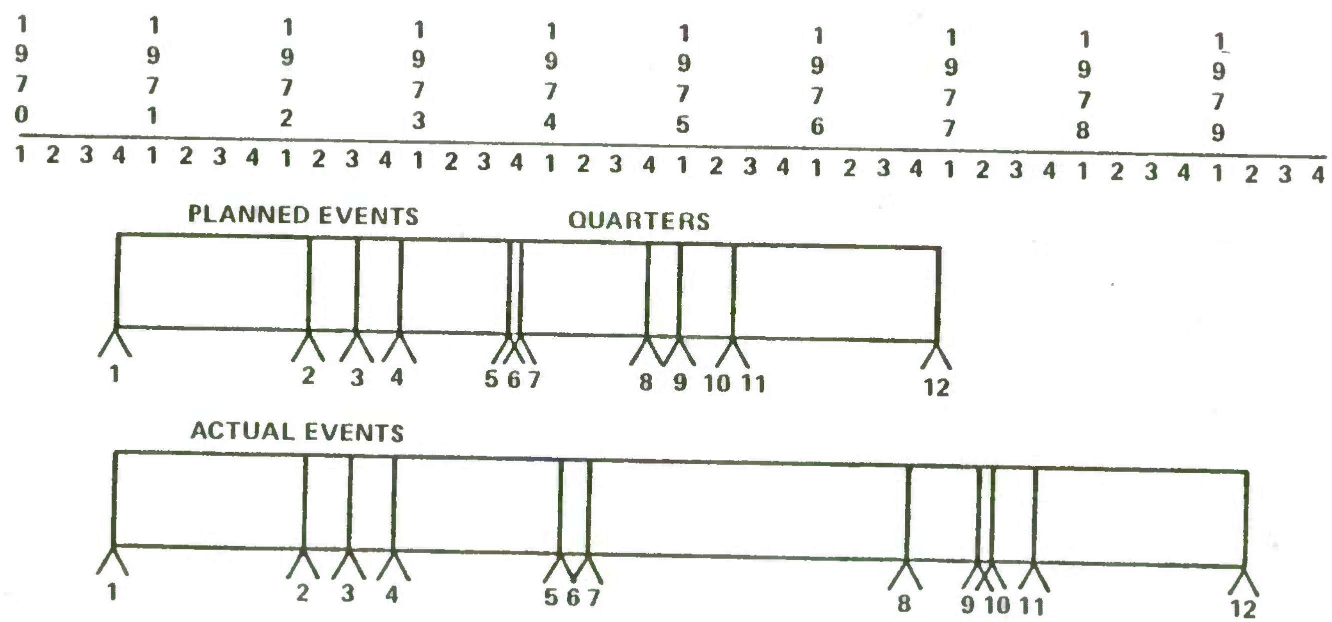
(4) These events are a function of the Congressional holding action. The option for one OSM was exercised in March 1975 with actual delivery in November 1976 (8 months). Testing of the OSM was correspondingly delayed. Although program delays are approximately two years at this point, once the one OSM was authorized for completion, the contractor cut four months off the original planned time for award and delivery of the OSM and two months off the originally planned time for at-sea testing. RDT&E budget cuts by Congress also contribute to the general slowdown in progress.

(5) Last three months delays due to preparation for DSARC III, expected in September 1977.

(6) At DSARC III approval, full scale production will occur; the estimated 27 month lag is necessary for set up of production facilities.

FIGURE E.16

CIWS EVENTS — PLANNED VERSUS ACTUAL



(8 months). Testing of the OSM was correspondingly delayed. Although program delays are approximately two years at this point, once the one OSM was authorized for completion, the contractor cut four months off the original planned time for award and delivery and two months off the originally planned time for at-sea testing. RDT&E budget cuts by Congress also contribute to the general slowdown in progress.

- Last three months delays due to preparation for DSARC III, expected in September 1977.

- At DSARC III approval, full scale production will occur; the estimated 27 month lag is necessary for set up of production facilities.

At this time, the CIWS appears to be operating at or over design requirements. As a result, production quantities (R&D plus procurement) have been increased to 437 units, 434 of which are to be produced between FY 78 and FY 83. 321 of the units are identified in the WPN appropriation for back-fit on operating ships; 113 are for new ships in the SCN appropriation; the remaining three are the RDT&E units.

(3) <u>The Estimate For Research And Development (R&D) Expenditures Shows A High Degree Of Accuracy</u>

R&D programs are notable for their cost growth. Development of new weapons is subject to unkowns of many kinds. Estimated costs for the CIWS in the R&D phase -- once the system requirements became fairly stable in 1972 -- are within two percent of projected costs.

The Decision Coordination Paper (DCP) for CIWS which reflected the first development philosophy shows an end cost estimate for R&D of $42.2 million. During the change in approach, this was raised $10 million and finally, once a new direction was developed, a cost of $123 million was estimated. The R&D estimate history from January 3, 1973 to March 31, 1977 is shown in Table E.77.

Table E.78 shows project cash flow since 1969 and it is clear that since the estimate was placed at the $121 to $127 million level, little variance from target has been experienced. Supplementary data regarding expenditures is shown as Table E.79.

(4) The Unit Cost Of The CIWS Rose 59 Percent From A Planned $1.54 Million To $2.44 Million

DCP #88 was prepared for DSARC II on the CIWS on 3 January 1973. At that time 368 production units and two prototypes were planned at a cost of $1.536 million per copy. The threshold stated in the DCP was $1.8 million per copy. The total RDT&E and procurement costs were estimated at $568.5 million. Table E.80 is a tabulation of these estimates and those discussed in subsequent paragraphs.

TABLE E.77

CIWS R&D COST HISTORY
($ in millions)

	DCP 1/3/73	SAR 6/30/73	SAR 9/30/73	SAR 12/30/73	SAR 3/31/74	SAR 6/30/74	SAR 9/31/74	SAR 12/31/74	SAR 3/31/75	SAR 6/31/75	SAR 9/31/75	SAR 12/31/75	SAR 3/31/76	SAR 6/30/76	SAR 9/30/76	SAR 12/31/76	SAR 3/31/77
Base - RDT&E	38.8	38.8	38.8	38.8	38.8	38.8	38.8	38.8	38.8	38.8	38.8	38.8	38.8	38.8	38.8	38.8	38.8
Prov. for Econ. Chg.	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Initial DCP Estimate	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2
Economic			2.3	2.3		1.3						2.9				-0.3	
Schedule																-0.9	
Support			2.7	2.7				+14.8									
Unpredictable		10.8	-	-		-1.0			+1.5								-0.1
Engineering				5.8								+17.9					
Quantity				14.7				-17.1				-14.2					
Addit. Eng. Chg.				27.1													
Addit. Support Chg.				15.1													
Estimating				2.4				-1.5									
Net Changes This Quarter		+10.8	-	+70.1	-	+0.3	-	-3.8	+1.5	-	-	+6.6	-	-	-	-1.2	-0.1
Previous Changes			10.8	10.8	80.9	80.9	81.2	81.2	77.4	78.9	78.9	78.9	85.5	85.5	85.5	85.5	84.3
Current R&D Cost As of SAR Dates	42.2	53.0	53.0	123.1	123.1	123.4	123.4	119.6	121.1	121.1	121.1	127.7	127.7	127.7	127.7	126.5	126.4

TABLE E.78

CIWS CASH FLOW FOR RESEARCH AND DEVELOPMENT

	1972 and PRIOR	1973	1974	1975	1976	1977	Late Request 1978
Authorized	$24,300,000	$14,420,000	$27,900,000	$15,000,000	$15,000,000	$ 19,900,000	$ 6,900,000
Cumulative		38,720,000	66,620,000	81,620,000	96,620,000	116,520,000	123,420,000
Spent	24,770,215	14,654,081	28,395,331	14,947,816	14,917,312	19,877,000	
Cumulative		39,424,296	67,819,627	82,767,443	97,684,755	117,561,755	
Excess/Deficit	(470,215)	(234,081)	(495,331)	52,184	82,688	23,000	
Cumulative		(706,349)	(1,201,680)	(1,149,496)	(1,066,808)	(1,043,808)	
Percent Variance	2%	2%	2%	- 0 -	- 0 -	- 0 -	
Average SAR Estimates	42,200,000	67,800,000	121,800,000	124,400,000	127,075,000	126,500,000	
SAR Estimate To Final	34	54	98	100.7	102.9	102.4	
Requested Funds	(66)	(46)	(2)	0.7	2.9	2.4	

TABLE E.79

CIWS SUPPLEMENTARY/EXPENDUTURE DATA

PROGRAM	FY 69/70	FY 71	FY 72	FY 73	FY 74	FY 75	FY 76	FY 77 R & D	TOTALS	PERCENT of total dollars spent	
In-House											
Ammo. Development	$252,274	$ 71,866	$ 30,000	-	$ 25,578	$ 65,000	-	$ 350,000	$ 794,718	-0-	
Engineering Support	428,200	225,331	208,087	$ 284,200	193,000	387,400	1,319,400	470,550	3,516,168	3.0	
Lethality Tests incl. DLD	-	155,800	-	-	-	5,320,000	2,263,500	3,359,000	11,098,300	9.0	
Tactical Missile Tests	-	-	-	-	1,651,832	2,767,900	100,000	-	4,519,732	4.0	
Test and Evaluation	112,500	224,000	343,200	933,100	498,500	60,000	413,000	3,303,000	5,887,300	5.0	
GFM/GFE	-	-	1,864	50,176	104,350	40,424	1,830	5,000	203,644	-0-	
									26,019,862		22.0
Contracts -- Outside											
Feasibility	$3,042,058	-	-	-	-	-	-	-	$ 3,042,058	3.0	
Engineering Development	-	$10,665,000	$8,874,000	$10,678,868	$2,430,675	-	-	$ 600,000	33,248,543	28.0	
Engineering Services	-	-	-	80,000	899,403	$ 460,786	$2,172,111	4,689,450	8,301,750	7.0	
Tactical Missile Tests	-	-	-	124,737	2,189,301	527,581	645,360	-	3,486,979	3.0	
OSM	-	-	-	-	13,398,000	-	5,000,000	-	18,398,000	16.0	
Training	-	-	-	-	-	139,866	-	-	139,866	-0-	
Production Engineering	-	-	-	-	3,939,692	4,000,000	1,806,000	2,100,000	11,845,692	10.0	
RMA	-	-	-	2,416,000	3,000,000	1,000,000	1,136,111	5,000,000	12,552,111	10.0	
Other	59,496	20,000	56,539	87,000	65,000	178,859	60,000	-	526,894	-0-	
Total Spending	3,894,528	11,361,997	9,513,690	14,654,081	28,395,331	14,947,816	14,917,312	19,877,000	91,541,893		78.0
									117,561,755		

TABLE E.80

CIWS COST GROWTH SUMMARY

	1/73	6/73	12/73	6/74	12/74	12/75	3/77 Current
R&D (1)	42.2	53.0	123.1	123.4	119.6	127.7	126.4
Procurement (1)	526.3	490.5	517.1	579.6	716.9	806.2	943.6
Program Estimate (1)	568.5	543.5	640.2	703.0	836.5	933.9	1070.0
Units	370	370	367	367	364	362	437
Average Unit Cost (1)	1.54	1.47	1.74	1.92	2.30	'2.58	2.45

(1) Figures in Millions of Dollars

Figures E.17 and E.18 show a breakdown of the overall cost growth from $568.5 to $1,070.0 million in constant FY 1972 dollars.

As of 30 June 1973, optimisim prevailed and the operative numbers were reduced. The 370 units were now to cost $1.469 million, making a program total of $543.5 million. This net reduction was attributed to (1) expenditures not included for FY 69-70 concept formulation and cost of firing tests against tactical missiles (+ $10.8 million); and, more importantly, (2) the production schedule re-structure involving benefits from the intermediate production (OSM) phase (- $35.8 million).

FIGURE E.17

PROPORTION OF MAJOR CATEGORIES TO TOTAL PROJECT COST CIWS

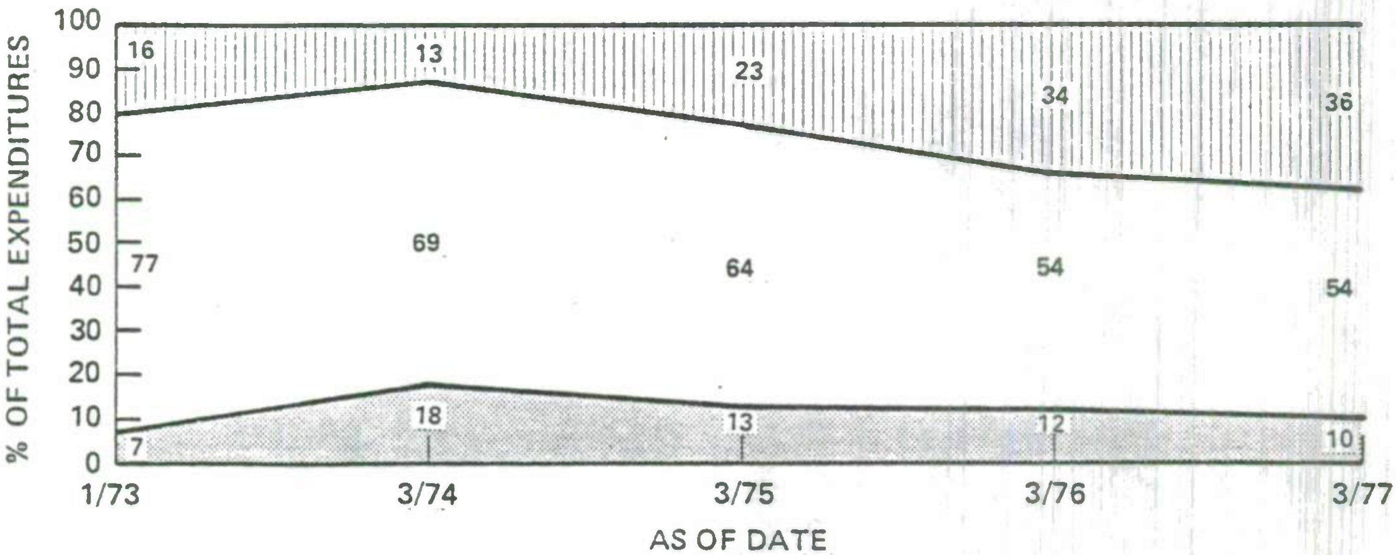
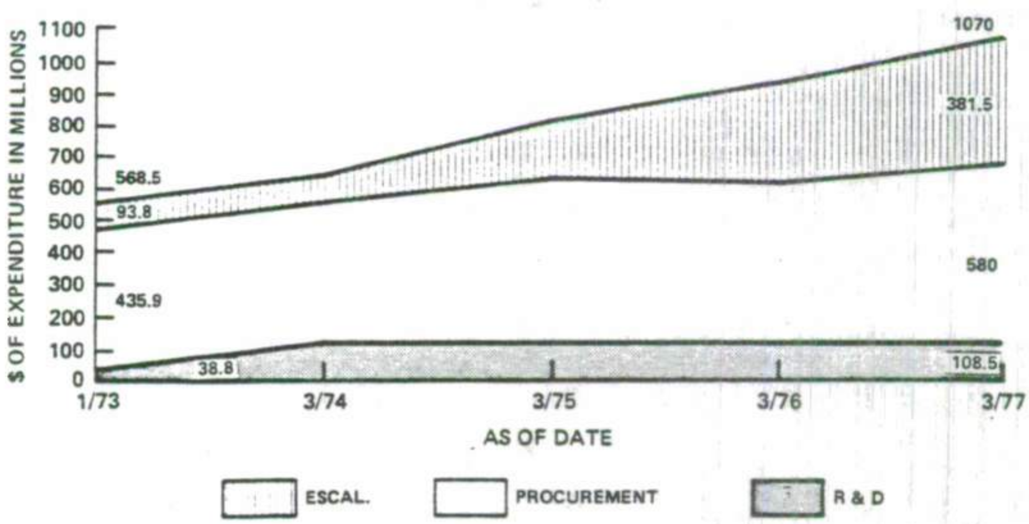


FIGURE E.18

DOLLAR GROWTH OF MAJOR CATEGORIES CIWS



SOURCE:
CIWS SELECTED
ACQUISITION REPORTS

The procurement plan estimated for the number of units to be purchased has remained fairly stable from program inception in January 1973 (368 units) until recently when the number of units increased to 434.

Several facts stand out in reviewing the reasons for the cost growth evidenced in the previous table.

- The prototype "fly-before-buy" decision and testing problem caused an adjustment in RDT&E costs; once the adjustment is made, however, it remained stable (total increase approximately $84 million)
- The procurement cost increase of $417 million is due primarily to --
  - An increase of 66 units valued at approximately $145 million.
  - About $270 million of escalation due to extension of building period from 1974-1977 to 1978-1983.

To explain the cost growth in more detail, the following SAR information is provided:

TABLE E-81

CIWS COST GROWTH ANALYSIS
($ in millions)

	------FY 1972 Constant----				
Cost Growth Categories	Development	Procurement	SubTotal	Escalation	Total
Development Estimate	38.8	435.9	474.7	93.8	568.5 (1)
Economic (a)	-	-	-	+52.7	+52.7
Schedule (b)	- 0.9	+25.9	+25.0	+88.5	+113.5
Estimating (c)	+ 4.4	+ 4.0	+ 8.4	+ 1.9	+10.3
Support (d)	+43.6	+14.9	+58.5	+43.1	+101.6
Engineering (e)	+29.7	+34.4	+64.1	+51.8	+115.9
Unpredictable (f)	+23.6	-23.2	+ 0.4	-	+ 0.4
Quantity (g)	-30.7	+88.1	+57.4	+49.7	+107.1
Total Changes Since DCP (1/73)	+69.7	+144.1	+213.8	+287.7	+501.5
Current Estimate	+108.5	+580.0	+688.5	+381.5	+1070.0 (2)

Current Estimate - Program Unit Cost $2.44 M
Original DCP Decision Program Cost $1.536 M
Original DCP Threshold Program Cost $2.00 M

(1) Based on two development units and 368 procurement units as of March 1973 SAR.

(2) Based on three development units and 434 procurement units as of March 1977 SAR.

As keyed to the letters on the preceding table, the following are the Navy's explanations of the growth as shown in the SAR format:

(a) This figure includes $1.3 million for development and +$51.4 million for procurement. This escalation reflects changes in OSD inflation rates over the R&D period, not as a result of changes or slippages in the program.

(b) The bulk of the growth is caused by a revised production period from FY 74 through FY 80 inclusive, to FY 77 through FY 83. The slippage was caused by denial of production funds and additional testing required by Congress. Also the production period was extended back to six years.

(c) The cost growth in estimating reflects four changes: 1) funds not originally programmed for CIWS (+$2.4 million); 2) funds spent for feasibility program in FY 69 and FY 70 (+$3.5 million); 3) FY 75 appropriation reprogramming (-$1.5 million); and 4) adjustment of FY 78 production learning curve from 87 percent to 90 percent (+$4.3 million WPN, +$1.6 million SCN).

(d) Added costs for: 1) expanded test and evaluation (includes test against tactical targets, +$38.7 million); 2) funds for final payment on OSM (+$14.8 million).

In the production support area: 1) denial of production funds (+$15.4 million), additional testing, increased material cost (+$4.4 million); 2) added spares for increased quantities; 3) recomputation of spares on a new percentage (20 percent) and slippage of spares procurement to FY 80 and FY 81; 4) reduction in SCN units which led to support reduction for AO 177 and CSGN.

(e) Development and implementation of design changes (+$91.1 million); and a higher RDT&E funding level for FY 77, 78 and 79 for contract cancellation costs, maintaining a small government and contractor team until FY 76/FYTQ budget approval, and funds to increase the CIWS capabilities (+$24.8 million).

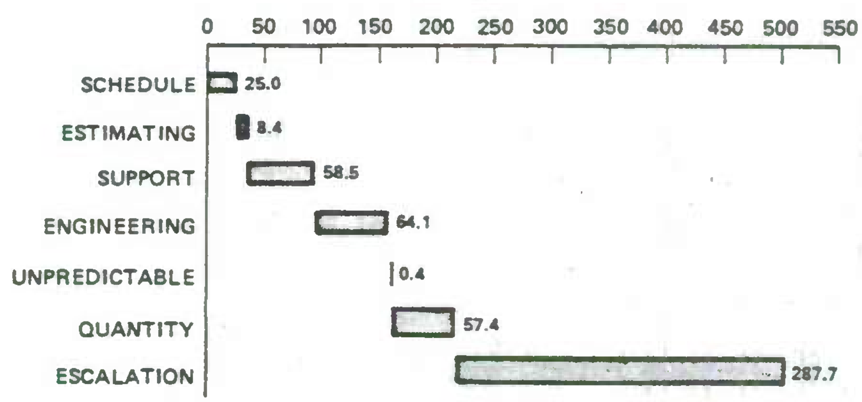
(f) Effect of reprogramming in FY 74-75 (+$0.5 million); Congressional reprogramming of $23.2 million from FY 73 to FY 74 RDT&E; and FY 78 budget request adjusted to $6.9 million from $7.0 million.

(g) Congressional reduction of FY 75-76 TQ requests equals decrease of five OSMs (-$35.3 million); Congress had originally transferred six units from procurement to R&D and then reduced the units to one. Also, the Navy made adjustments: 1) +$75.5 million/35 units FY 79-83 WPN; 2) -$19.3 million/-eight units FY 78 SCN; 3) +$111.0 million/60 units FY 79-83 SCN. Later SCN units were reduced -- AO 177-179 lost six units (-$15.7 million) and CSGN lost six units (-$9.1 million).

To summarize, then, the cost growth is at least 57 percent escalation, another 11 percent for quantity changes, 13 percent for engineering and 12 percent for support costs. The chart following illustrates this.

FIGURE E.19

SUMMARY OF CIWS COST GROWTH BY CONTRIBUTING FACTORS ($ IN MILLIONS)



SOURCE:
CIWS SELECTED
ACQUISITION REPORTS

(5) <u>The CIWS Project Being R&D Oriented Has Been Characterized By Developmental And Engineering Problems</u>

The following is a summary of the kind of problems which characterize the program:

- In 1973 --
  - The weight of the prototype exceeded the DCP threshold of 11,000 pounds, with a full magazine of ammunition. The prototype weighed in at 11,700 pounds with an additional 200 pounds expected for increased electronics cooling capacity. This problem is not expected to affect the abilities or use of the CIWS, but weight reductions will be contemplated in the OSMs.
  - Additional funds and time was alloted to conduct tactical firing tests of the system against warhead configured missiles.
  - At-sea testing of Prototype #1 on the U.S.S. KING against towed targets proved accurate in most cases.
  - The reliability, maintainability and availability proofing effort on Prototype #2 was extended one year to redesign the high voltage power supply and RF transmitter.
  - Congress decided to keep the CIWS program in the R&D stage for further testing and to increase its capabilities.
- In 1974 --
  - Further testing of Prototype #1 on the U.S.S. KING proved the system below specifications in the area of system reliability.

- Further concerns by Congress led to the requirements of 1) additional testing against tactical missile targets carrying live warheads; and 2) additional research to develop and evaluate growth options to meet future threats.

- Prototype #1 fell below specifications in availability. Additionally, the testing showed the need to improve remote control instrumentation, improve generator power supply reliability, and improve control procedures.

- In addition, the prototype has shown a tendency to track and declare as threats large objects such as stationary land masses.

. In 1975 --

- Testing of Prototype #1 was hampered by mooring and weather problems.

- A large percentage of the tests scheduled to be conducted on Prototype #1 after installation at the Navy's land-based test site at St. Nicholas Island were not completed. Some of the cancellations were due to system failures.

- During the testing at St. Nicholas Island, some problems developed in firing tests against low flying aerial targets. The difficulties were attributed to computer software problems.

- The CIWS tracks its own projectiles to correct aiming deficiencies and the testing has shown results below required specifications.

- Testing has shown some problems in hitting the crucial areas of the target.

- The International Machinist Union at General Dynamics went on strike in June 1975. Management and non-striking personnel continued to work on the OSMs, but some delays occurred.

- By June 1975, the reliability and availability of both Prototype #1 and #2 had increased. Prototype #1 had demonstrated a MTBF slightly below specifications and availability which met specifications. Prototype #2 averaged at an even higher percent availability due to its reliability upgrade effort.

- Congress withheld funds for FY 76 because of inadequate testing against realistic targets and possibility of early obsolescence.

In 1976 and 1977, continuing reliability upgrade programs on Prototype #2 and lessons learned from at-sea testing of Prototype #1 have helped to correct many of the problems and deficiencies of the CIWS.

The testing of the CIWS Operational Suitability Model has been encouraging. The firing record against selected targets has been excellent. Reliability has also improved. The current MTBF is significantly higher than the DCP/SOR specifications. The OSM was able to function over a sustained period without any maintenance.

In addition, the system has improved significantly in detecting selected targets against large background objects.

(6) <u>NAVSEA, Starting With The Hardware Procurement Cost, Estimates The Cost Of Installation Add-Ons</u>

Two appropriations are applicable for CIWS budgeting.

- WPN appropriation for back-fitting CIWS during overhauls on ships of the fleet.
- SCN appropriation for CIWS installation on new ships or modernization programs.

The estimates prepared for these appropriations reflect add-ons for cost necessary to install, test and prove the weapon on a ship. These vary, of course, on whether the ship is in new construction or alteration.

The present practice of NAVSEA 01G in estimating for the SCN budget is shown in Tables E.82 and E.83. It is significant to note the basic hardware cost of the CIWS compared with the costs after the addition of supporting and installation charges which shows a difference of over $3 million for the FY 77 lead system. Of this total, $61,000 applies to the CIWS gun itself. Almost $640,000 applied to engineering support charges. In addition there are substantial installation charges included in each ship estimate. The CIWS project office and SEA 01G disagree on costs for engineering support and installation. Costs will vary between ship types, but based on actual costs during R&D, the CIWS Project Offices rates

TABLE E.82

NAVSEA 01G COST ESTIMATES -- CIWS
(All Ships)
(Dollars in Thousands)

	Lead System FY 77 Estimate	Lead System FY 78 Estimate	Follow System FY 77 Estimate	Follow System FY 78 Estimate
A. Equipment Costs				
Hardware	2,600	2,615	2,600	2,615
Remote Control Indicators	85	-	85	-
Peculiar Support Eng.	130	-	130	-
Production Support	127	-	127	-
GFE - gun	61	60	61	60
Ordalts	30	-	30	-
Shipping Fixtures	12	13	12	13
Project Management	12	13	12	13
I & C Spares	150	268	150	268
Design Eng. Changes	601	268	601	268
Test Equipment	73	79	73	79
Initial Spares/Support	480	536	480	536
Tech. Data, Doc., OD's	58	50	23	9
ILS Management	49	14	49	14
QA and RMA	84	11	84	11
	4,552	3,927	4,517	3,886
Growth 10%	455	393	452	389
	5,007	4,320	4,969	4,275
B. Engineering/Support Related (See Table 5A)	639	647	289	305
C. Total Estimate: Equipment/Support Costs	5,646	4,967	5,258	4,580
Projected 1979 Estimates		5,295		4,882

TABLE E.83

NAVSEA 01G COST ESTIMATES -- CIWS
INSTALLATION COSTS
(Dollars in Thousands)

	Lead System FY 77 Estimate	Lead System FY 78 Estimate	Follow System FY 77 Estimate	Follow System FY 78 Estimate
A. Installation/Support Related Cost				
PHS & T	18.5	20	18.5	20
Firings	26.8	29	5.5	6
CAMS	13	14	11.1	12
EMC	13	14	4.6	5
SOS	1.8	2	1.8	2
Publications	3.7	4	3.7	4
SEA 651 Sys. Eng.	49.8	54	18.5	20
COT	14.8	16	9.2	10
	141.0	153.0	73.0	79.0
B. Engineering Support				
Contractor Field Eng. Serv.	80	91	40	50
Gov't. Field Eng. Serv.	134	100	67	59
Systems Engineering	185	200	42	45
SQT	41	44	41	44
	440	435	190	198
Growth 10%	58	59	26	28
C. Total Engineering/Support Related Costs	639	647	289	305

NOTE: Source for all numbers and assumptions is NAVSEA 01G.

the NAVSEA 01G estimates as high. There is little disagreement between NAVSEA 01G and the project office over the hardware estimates.

NAVSEA 01G utilizes a generalized format involving certain percentages for supporting costs (according to some sources there is no rationale for the percentages used). For example, the percentages used for design engineering charges and various field and systems engineering changes were high. The reason for this is the extensive R&D which involves prototypes and OSMs, and the fact that CIWS is a stand-alone system.

The SEA 01G generalized format is based on weapons systems requiring extensive engineering and integration, complicated installation and extensive testing. No attempt is made to examine weapon systems on an individual basis to determine individualized supporting and installation charges required. Presently, there are still some small disagreements between NAVSEA 01G and the CIWS project office on the CIWS pricing philosophy.

The estimates for WPN units also have add-on charges, but not to the extent used for SCN. The WPN figure for FY 1977 is estimated at $3.2 million -- a 23 percent increase over basic hardware costs as opposed to over a 100 percent increase in SCN estimates.

(7) The Project Team For CIWS Is A Small Result -Oriented Group

The CIWS project group is small, well-managed and enthusiastic about the Close-In Weapons System. This attitude and dedication is reflected in the progress of project events.

Cost-related decisions are made after careful review of information provided by several sources.

- General Dynamics, the CIWS contractor, has an extensive estimating and cost control section under the direction of the Assistant Controller. Two estimates are made in this division, totally independent of each other. The first estimate is an engineering estimate based on actual data utilizing the first prototype as the baseline. The engineering estimate is compiled by an in-house computer system called Automated Inter-Divisional Estimating System (AIDES).

- The second independent estimate is a parametric estimate developed by utilizing the RCA Computer Cost Prediction Model (PRICE). The PRICE parametric estimates have been extremely accurate to date when compared with engineering estimates.

- Two men in General Dynamics' Computer Support Group have been trained to use the PRICE system which is accessible through a terminal provided by RCA. The input data goes through any of three software contractors so RCA has no access to the data.

- General Dynamics has also developed an extensive data bank based on:

  - Monthly reviews of financial position and problems encountered

- Accounting work orders
- Summarized costs in the Work Breakdown Structure format
- Information from AIDES and PRICE

. General Dynamics utilizes many ship and engineering people to help prepare estimates.

. General Dynamics prepares and negotiates overhead and direct labor rates yearly for three years in advance.

. The material cost estimating group continuously reviews the cost of commodities for material cost and predictions.

. General Dynamics also develops their own weighted inflation index which has been fairly close to DOD indices.

. A completely independent contractor, Tecolte Research, Inc., prepares an independent parametric estimate based on contractor return cost data. Tecolte has a small staff of people educated in engineering, mathematics, physics and economics which provide research, analysis, engineering and consulting services to government and private agencies. Their cost analysis/estimating experience is between 10 and 15 years.

In the case of the CIWS, Tecolte prepares a parametric estimate based on cost estimating relationships. The data used is obtained through Contractor Cost Data Reports (CCDRs), Cost Information Reports (CIRs) and data solicited from contractors by Tecolte, themselves.

. When these estimates are received by the CIWS project office, staff and management review and compare them. The CIWS management maintains rigid control over changes in cost estimates by monitoring and questioning all significant variations.

. Further, special contract clauses (not defined as part of DOD INST. 7000.2) outline returned cost breakdown required by the project office. The reports are based on existing contractor Management Information System (MIS) output which are also relevant to CIWS management activities. Typical reports include:

- Actual costs against bid estimates showing cost-to-complete on a monthly basis;
- Performance report based on Work Breakdown Structure (WBS) and functional organization;
- Manpower loading by WBS and functional organization;
- Material Cost by major cost element;
- Milestone schedule and progress.

The amount and quality of data utilized by the project office is well thought out and useful in decision-making activities. The noteworthy performance of the project office in adhering to budgeted costs of R&D and procurement can be attributed to the well-managed project group, experienced and dedicated contractor personnel, independent cost estimators, and timely information.

* * * * *

The following is a summation of the cost estimating process for the Close-In Weapon System (CIWS).

- Staffing and Organizational Structure -- There are no estimators as such in the CIWS project office, but the business manager is directly involved in verifying General Dynamics and Tecolte estimates.

- Data Banks -- Extensive data bank information is available in the CIWS project office in the form of return cost data, and the Tecolte independent estimates.

- Return Cost -- Much data is available. The project office feels that much of the required DOD INST. 7000.2 return cost data is too late and too complicated to be useful. Special contract clauses are now included in CIWS contracts specifying the data the CIWS project office desires to track costs and estimate changes, i.e., actual costs versus bid estimates including cost-to-complete information, performance report based on WBS, etc.

- Escalation and Inflation Predictions -- The CIWS project office utilizes WPN escalation rates which they feel reflects the price they expect to pay the contractor for the first production run or the General Dynamics weighted index.

  Tecolte has utilized various indices such as the Wholesale Index Category 117, the Consumer Price Index, Program Objectives Memorandum Indexes, and their own in-house index for the CIWS independent cost estimates.

- Quality versus Technical Data -- The technical information on the CIWS is becoming more extensive and accurate. The project has had two prototypes and an Operational Suitability Model to develop accurate and detailed technical data on which to base cost estimates.

  This information is used for validation by the CIWS project office.

- <u>Estimating Response</u> Time -- Estimates can be obtained quickly by the CIWS project office from both General Dynamics and Tecolte. General Dynamics utilizes the Automated Inter-Divisional Estimating System (AIDES) to provide engineering estimates and PRICE, and RCA system used to compute parametric estimates. Tecolte provides independent parametric cost estimates.

  Both firms have extensive and well-organized data banks and General Dynamics usually can predict cost estimates five years in advance to coincide with the Five Year Defense Plan.

- <u>Review Procedures</u> -- The CIWS project office maintains extensive return cost data in compliance with DOD INST. 7000.2 as well as information specifically requested from GD for cost monitoring.

- <u>Technical Complexity of Estimates</u> -- The technical complexity of the estimates provided by General Dynamics are very extensive. General Dynamics can give estimates for all 77,000 parts in the CIWS system.

7. THE AN/UYK-7 HAS A MODULAR DESIGN SPECIFICALLY DEVELOPED FOR ALL-PURPOSE USE BY THE NAVY

In order to avoid certain problems associated with the proliferation of Navy tactical computers, the Chief of Naval Operations directed the development of a general purpose digital computer which the Navy could standardize for shipboard applications in the 1970's; the AN/UYK-7 Computer was developed in response to this direction. The computer's modular construction makes it readily adaptable to a wide range of shipboard applications including those of both specialized and general natures and can be installed on all type ships.

The AN/UYK-7 is a general purpose, stored-program, solid state, binary computer designed for real time applications in various naval shipboard processing systems. For weapon systems, the computer performs the data processing and computations needed for target tracking; generation of gun, torpedo and missile orders; and for providing display data to fire control systems and tactical data system operators.

The AN/UYK-7 is installed in cabinets or bays in various combinations of the following units.

- Central Processing Unit (CPU)
- Memory Unit (16,384 words, 32-bit) (32,768 words, Double Density Memory)
- Input/Output Controller (IOC)

- Power Supply Unit
- Dummy Unit
- I/O Adapter (4,8,12 or 16 channels)
- Cabinet
- Maintenance Console Unit
- Remote Operating Console Unit

Each central processor is capable of addressing a maximum of 16 memory units and four IOC's. The memory units are capable of being addressed by any combination of central processors and IOC's, within the constraint that the total number of required accesses is limited to eight.

The basic computer configuration consists of one CPU with three memory units, and the minimum configuration is one CPU and one memory unit.

Each CPU has a 512-word nondestructive readout containing two 96-word "bootstrap" programs and a diagnostic program. Memory cycle time is 1.5 microseconds, and the maximum data transfer rate per second per channel is 167,000 words, or 10 megabits per second with optional bit-serial channels.

(1) <u>The AN/UYK-7 Is A Well Defined Third Generation Computer</u>

The initial Procurement Request (PR #98946) to purchase AN/UYK-7 Computers for the DXGN (now CGN) was released on 30 November 1968. Subsequent PRs were released as follows:

PR #98946.1 ASMS (Advanced Ship Missile System) on 29 January 1969

PR #98946.2 LHA on 30 January 1969

PR #98946.3 DX (DD 963 class) 19 February 1969

All of the above PR's were combined for procurement under Contract N00024-69-C-1402 dated 12 August 1969 from the UNIVAC Defense Systems Division of Sperry Rand Corporation. Since the initial contract, there have been approximately twelve Navy sole source firm fixed price contracts with Sperry Rand, the latest being N00024-77-D-7121 of 25 March 1977. Approximately 348 AN/UYK-7 Computers have been procured by the Navy which is the sole procuring agent of the Department of Defense for this sytem.

(2) <u>The Cost Of Procurement Was Well Established From Numerous Past Acquisitions</u>

The initial cost estimate of approximately $524,000 for the AN/UYK-7 to be furnished for the Advance Ship Missile System (ASMS - now AEGIS) was generated by the Computer System Section of NAVSEC. Because of their previous computer procurement experience and the standard nature of the components involved, the above initial cost estimate was based on a well-defined baseline. This no doubt contributed to the fact that the actual cost of the ASMS computer (approximately $534,000) was within $10,000 of the NAVSEC 6178 estimate.

NAVSEC 6178 is the technical manager for the AN/UYK-7 while NAVSEC 6172 determines the peripheral equipment required for a specific ship/ship class tactical data system. The actual Procurement Request for the computers is initiated by SEA 04.

For the SCN Budget process SEA 0442, the SCN Support Section, provides AN/UYK-7 Computer cost estimates to SEA 01G for ships listed in the Program Objectives Memorandum (POM). The estimate is based on the most recent bid proposals from the manufacturer, Univac-Sperry Rand, and includes the current inflation factor being used by the contractor. The cost of the AN/UYK-7 is presently stable since the manufacturer's output is at capacity. It should be noted that the Navy is the sole procuring agent for all AN/UYK-7's. The availability of current price and bid information appears to be of significant value to the estimating process as this information is used to the exclusion of parametric or engineering estimating methods. In providing estimates for new requirements, factors for escalation and other growth are developed by SEA 0442 from knowledge of active contract information and not from SEA 01G guidance.

SEA 045 prepares Procurement Requests (PR) in accordance with the requirements presented by the DOD at a UYK-7 pre-production conference. At this time, the various Ship Acquisition Project

Manager's (SHAPM's) computer requirements are provided SEA 045 via "data ordering sheets" based on Ship Project Directive (SPD) information. SEA 045 then generates a PR which consolidates all DOD requirements.

Code 04513 uses NAVMAT form 5230/15 (Procurement Planning Guide Worksheet) for information purposes. This computer-generated form contains contract prices, hull numbers, award dates, scheduled delivery dates, contract number, description of the item or unit, has proved valuable in providing cost data and in isolating applications to a specific hull.

(3) The Many Different Configurations Of The AN/UYK-7 Makes Cost Analysis Of Questionable Value

By definition, a standard AN/UYK-7 cabinet consists of a central processing unit, an input-output controller, three memory units, an input-output adapter, and a power supply. However, the capacity of the computer system is easily expanded through additional modules. This flexibility has resulted in many configurations, all "tailor made" to fit a specific application. Currently, the following configuration designations exist for the AN/UYK-7 Computer.

(1)	1 Bay-single density	NOTE: Double density indicates that there is double the amount of word capacity on the same size card as the single density.
(2)	1 Bay-double density	
(3)	2 Bay-single density	
(4)	2 Bay-double density	
(5)	3 Bay-single density	
(6)	3 Bay-double density	
(7)	4 Bay-single density	
(8)	4 Bay-double density	

The flexibility in the configuration of the AN/UYK-7 computer for different applications .results in widely varying dollar amounts being reported in different budget forms for different ship classes.

The magnitude of the dollar differences that may arise is illustrated by the following data taken from FY 1975 budget back-up forms itemizing AN/UYK-7 Computer estimates.

Ship Class	Estimate	% Difference
FFG-7	$ 437,000	--
SSN-688	596,000	36%
CGN 38	1,587,000	263%

(4) Estimating Costs Of The AN/UYK-7 Is Not A Problem

Cost data collected indicates that the procurement cost of the AN/UYK-7 has decreased significantly since the initial hardware contract dated 12 August 1969. This is illustrated by comparison of the prices in this contract with the prices in the latest contract which is dated 25 March 1977. The initial contract was for

17 1-bay computers an final price $7,171,719. The March 1977 contract procured 17 1-bay computers plus 2, 3 and 4-bay computers. The 17 highest priced 1-bay computers total $5,330,600, or 35 percent less than the initial buy price.

SEA 045 recently made a comparison of the basic cost of an equivalent 1-bay single density computer during the period 1972 to 1977 with the following results.

Contract N00024-	Basic Cost Per Equivalent "Standard" Computer
72-C-1327	$304K
72-C-1256	247K
73-C-1327	228K
74-D-1193	223K
75-D-7165	225K
76-D-7195	231K
77-D-7121	279K

The above basic costs have remained almost stable with a 9 percent decrease from 1972 to 1977 which is significant in view of the high inflation experienced by many of the Navy programs.

The above data indicates that cost estimating has not been a problem. Cost overruns have not been experienced in AN/UYK-7 contracts. The large number of computers procured over a seven to eight year period with UNIVAC at maximum production has provided

production stability with resulting monetary savings for the Navy.

*　　*　　*　　*　　*

The following summarizes the cost estimating process for the AN/UYK-7 Computer.

- <u>Staffing and Organizational Structure</u> -- Neither NAVSEA nor NAVSEC are organized or staff to estimate computer costs. SEA 044 provides cost estimates for the POM/budget process which are based on bid proposals and current contract data.

- <u>Data Banks</u> -- A quantity of data exists in SEA 045 files and procurement contracts.

- <u>Return Costs</u> -- Contract prices were available.

- <u>Escalation and Inflation Predictions</u> -- The inflation predictions are those used by the manufacturer, UNIVAC - Sperry Rand.

- <u>Quality Vs. Technical Description</u> -- Complete technical documentation is available. Cost estimates are based on past contract and bid proposals.

- <u>Estimating Response Time</u> -- Estimates are developed quickly. SEA 044 and SEA 045 have all the data necessary to "tailor make" a cost estimate as required.

- <u>Review Procedure</u> -- SEA 044 estimates are not usually reviewed by other than normal supervisory procedures.

- <u>Technical Complexity Of The Estimates</u> -- It is a "third generation" computer within the state of the art and accurate engineering estimates can be developed as required.

8. THE LM 2500 MARINE GAS TURBINE ENGINE, DEVELOPED FROM THE C5A AND COMMERCIAL VERSIONS OF TURBOFAN ENGINES, IS THE NEWEST AND MOST ADVANCED MARINE GAS TURBINE ENGINE USED BY THE NAVY

The LM 2500 is a simple-cycle, two-shaft engine consisting of a gas generator, power turbine, fuel control and governing system, associated inlet and exhaust sections, lubrication and scavenging systems, and controls and devices for starting and monitoring operation of the engine. It is available as a gas turbine alone, as a base-mounted unit, or as a completely packaged module. The engine incorporates:

- a 16-stage compressor
- a full annular, dual fuel burning combustor with externally mounted fuel nozzles
- a two-stage high pressure gas generator turbine, air cooled, that drives the compressor and accessory drive gearbox
- a six-stage-low speed, low-stress power turbine, with an output speed of 3600,rpm, which is coupled aerodynamically to the gas generator and is driven by its high energy release exhaust flow

The LM 2500 marine gas turbine module is a compact marine propulsion unit suitable for both naval and merchant ship application. It is com-

posed of four distinct configuration items:

- Base/Enclosure Assembly
- Gas Turbine Assembly
- GT Lube Storage and Conditioning Assembly
- Free Standing Electronic Enclosure Assembly

Designed for easy installation in space-limited engine compartments, the module weighs 42,000 pounds (44,000 with shock mountings) and occupies a space of only 8 x 9 x 26 feet. Use of the LM 2500 module simplifies installation, makes better use of available space, suppresses engine room noise, provides for ice detection and removal in the air intakes, and provides for fire detection and extinguishing. The shock mounting system attenuates noise into the ship's foundation as well as high intensity shock transmission into the engine.

Advantages of using LM 2500 marine gas turbines for powering ships may be summarized as follows:

- Space savings -- Because of the low volume more space is available for fuel, armament, cargo, etc. The module takes up less space than the main condenser of a steam plant of equal horsepower, occupies about the same space as one cylinder of a low-speed diesel engine of the same power rating.
- Reduction in installation costs -- Modular design and low weight reduce overall time and cost of installing the propulsion system.

- Greater ship availability -- Ship availability is assured by swift component and engine maintenance or removal made possible by modular design and split casings. LM 2500 can be back in operation in hours, while repairs to a conventional propulsion plant might require weeks or months.

- Lower fuel consumption than other gas turbines -- The cycle efficiency of the LM 2500 is greater than other presently available gas turbines. This reduces operating costs and provides longer range.

- Manpower requirements reduced -- The LM 2500, designed for unattended operation, is readily integrated into a ship's automated control system and, when combined with a central operations system, can reduce manning requirements of the engine department by as much as 65 percent.

- Fuel flexibility -- The LM 2500's ability to operate on a variety of fuels gives ships more options in time of fuel scarcity or when operating in overseas areas.

- Rapid ship response -- When power is needed , the LM 2500 can respond quickly. From a "cold engine" condition, the LM 2500 normally can achieve full power in 60 seconds. Further, it can accelerate in about five seconds from idle to maximum torque, and in about four seconds can back off from full power to idle.

(1) <u>The Navy LM 2500 Marine Gas Turbine Engine Program Provides For Use Of The Engine In New Construction, Procurement Of Replacement/Spare Parts, And A Component Improvement Program</u>

In December 1969, the Navy installed its first LM 2500 marine gas turbine on the GTS ADMIRAL WILLIAM M. CALLAGHAN, a high speed roll-on/roll-off cargo ship built for charter to the Military Sealift Command. This engine replaced one of the two first generation gas

turbines that originally powered the CALLAGHAN. In 1973, the Navy replaced the remaining first generation gas turbine with another LM 2500 engine. Tens of thousands of hours of at-sea testing under destroyer operating profiles have been completed by the CALLAGHAN; thousands of additional hours of shore-based Research, Development, Test and Evaluation (RDT&E) testing have been accomplished at the Naval Ship Engineering Center (NAVSEC), Philadelphia Division. The principal ship classes for which the LM 2500 has been selected as the main propulsion engine are:

- SPRUANCE (DD-963) Class Destroyers -- 30 ship program, first in class commissioned September 1975; 4 gas turbine modules per ship; total of 120 LM 2500 modules.

- Guided Missile Frigate (FFG) -- 74 ship program; 2 gas turbine modules per ship; total of 148 LM 2500 modules; option agreement with General Electric Company for 30 ship sets (60 modules).

Other ship classes for which the LM 2500 has been selected as the main propulsion unit are:

- AEGIS Destroyer (DDG-47) -- Propulsion plant same as DD - 963; 4 gas turbine modules per ship.

- Patrol Combatant Missile Hydrofoil (PHM) -- 1 LM 2500 gas turbine per ship; no module as in DD 963 and FFG class ships, engine room itself serves as container for engine.

- Patrol Gunboat Missile (PGG)
- Patrol Chaser Missile (PGC)
- Sea Control Ship (SCS)
- Surface Effect Ship (SES) -- six LM 2500's, two for lift and four for drive.

Programs for these ship classes have been cut back or are of such small size that at present the DD 963 and the FFG programs are many times greater than any of the other programs utilizing the LM 2500. Moreover, both the DD-963 and the FFG utilize the LM 2500 marine gas turbine module, whereas some of the other classes utilize special LM 2500 configurations. For these reasons, the LM 2500 modules used for the DD 963 and FFG classes are the units that have been tracked in connection with cost estimates and actual costs associated with LM 2500 installations in new ship construction.

Another element of the Navy LM 2500 marine gas turbine engine program is the procurement of replacement/spare parts for the LM 2500 installations on ships by the Fleet Support Directorate (SEA 04), Naval Sea Systems Command. Modules are not bought, but rather:

- gas generators
- turbines in reuseable storage containers
- piece parts for the oil module
- trays for the FSEE (Free Standing Electronic Enclosure)

At the beginning of the DD 963 program, the power plants were to be Pratt & Whitney (P & W) FT9 gas turbines. Subsequently, General Electric entered the competition to supply the power plants, and in 1970 Litton selected (the power plants were CFE-Contractor Furnished Equipment rather than GFE-Government Furnished Equipment) the LM 2500 marine gas turbine for use in the DD 963's. Navy did not object because the LM 2500 was a second- generation marine gas turbine, whereas the P & W engine was a first generation marine gas turbine; moreover, the change from the P & W engine to the LM 2500 would result in no additional cost to the Government. The Litton/General Electric agreement provided for the procurement of 120 LM 2500 modules at about $1.1 million each or 64 modules at about $1.28 million each, and provided for price escalation.

The Litton/General Electric agreement has the following specifications for the LM 2500:

- <u>TBO (Initial Time Between Overhaul)</u> ------------ 6,000 hours
- <u>Projected TBO based on operating profile for ship</u> -- 9,000 hours
- <u>MTBPER (Minimum Acceptable Mean Time Between Premature Engine Removals)</u> --------------------10,000 hours

The Fleet Support Directorate, SEA 04, considered the 6,000 hour TBO figure to be too optimistic. Further, Navy does not use the terminology TBO,

but, rather, MTBR (Mean Time Before Removal). TBO is the same as MTBR only for the first removal. For the LM 2500's on the DD 963's, a joint MTBR estimate by the Naval Sea Systems Command (NAVSEA 04T), the Naval Ship Engineering Center (NAVSEA 6146), and the General Electric Company was subsequently developed and was considered to be accurate. The estimate was based on actual experience and monitoring of the LM 2500 on the GTS ADMIRAL WILLIAM M. CALLAGHAN, and is as follows:

<u>MTBR (Mean Time Before Removal)</u>

Gas generator -- 3,500 hours

Power turbine -- 4,000 hours

These figures are the ones used in connection with preparing budget estimates, not the General Electric TBO figure of 6,000 hours. The possibility exists that even the MTBR figures of 3,500 and 4,000 hours are overly optimistic because, as of the end of July 1977, there have been eight LM 2500's removed from the DD 963's with no more than 2,000 hours on any one.

In an effort to reduce spare LM 2500 gas generator and turbine requirements, a Component Improvement Program (CIP) -- the third element of the Navy LM 2500 marine gas turbine engine program -- was contracted for with General Electric. Goals of this program are as follows:

MTBR (Mean Time Before Removal)

Gas generator -- 9,000 hours by about 1990

Power turbine --10,000 hours by about 1990

Specific efforts conducted under the Component Improvement Program (CIP) are:

- Flowpath improvements
- Greater durability through redesigned combustors, turbine shrouds, and turbine vanes
- Improved and more durable HPT (High Pressure Turbine) blades and vanes
- Flexible coupling alignment criticality
- Improved reliability and maintainability of the 28 volt dual power dupply (engine shutdown problem)
- Correct deficient starter lubrication
- Improved reliability of the gas generator 4B thrust bearing.

In terms of life-cycle costs for the LM 2500, costs of the Replacement/Spare Parts Program and the Component Improvement Program are of considerable magnitude and significance. Nevertheless, costs of these programs do not comprise any part of LM 2500 cost estimates used in preparing new ship construction cost estimates contained in Shipbuilding and Conversion, Navy (SCN) appropriation budget estimates submitted to Congress.

(2) <u>Cost Estimates For The LM 2500 Are Generated By Several Organizations</u>

Cost estimates relative to LM 2500 marine gas turbine modules for use in new ship construction have been and are being generated by several organizations:

- NAVSEA 01G (Cost Estimating and Analysis Division of the Plans, Programs and Financial Management/ Comptroller Directorate, Naval Sea Systems Command).
- SHAPM's (Ship Acquisition Project Managers, Naval Sea Systems Command) for ships utilizing the LM 2500. For example, the Guided Missile Frigate (FFG) Ship Acquisition Project Office, and, more specifically, PMS 399P4 within that office.
- SUPSHIP (Supervisor of Shipbuilding) Bath, where the Bath Iron Works is acting as agent for the Navy in buying LM 2500 modules under the terms of an option agreement covering the procurement of 60 LM 2500 modules for FFG ships.
- Naval Ship Engineering Center (NAVSEC), where NAVSEC 6146 provides estimates as called for by the SHAPM's, particularly at the beginning of a project.
- General Electric Company, the vendor for the LM 2500 marine gas turbine modules.

(3) <u>The Methodology For LM 2500 Cost Estimating Is Not Standardized</u>

The General Electric Company/Bath Iron Works Corporation 1973 option agreement covering the purchase of thirty LM 2500 shipsets (60 modules) for FFG ships has as the starting point for any cost estimating

certain firm fixed prices for contract products consisting of:

- Follow - On Gas Turbine Modules (Shipset)
- Data (DD 1423 Items) (Shipset)
- Special Tools for Shipboard Maintenance
- Engineering Support Services (Shipset)

Such base prices vary slightly according to specific year of delivery. Exercising the options with certain contract provisions involved would result in option prices as follows, in terms of unescalated October 1972 (FY 1973) dollars:

Base price per module	$1.398 million
Potential reduction for deleting warranty	.058 million
Potential reduction for deleting product improvement	.034 million
Potential price	$1.306 million

Adjustments are made to these prices on the basis of authorized changes to the contract products and changes in a material index which is based on the arithmetic average of the following three (3) indices furnished by the Bureau of Labor Statistics of the U.S. Department of Labor:

- Labor Index - The Average Hourly Earnings of Aircraft Engine and Engine Parts Production Workers. (SIG - 3722).

- Material Index - The Metal and Metal Products Wholesale Price Index (Code 10).

- Wholesale Price Index - Industrial Commodities

Escalation for progress payment periods is computed using the following equation:

OP x [(PP-LP) x (AI)] = Escalation

OP = Option Price
PP = Present Progress Percentage
LP = Last Reported Progress
AI = Average Index Percentage Change

The General Electric/Litton option agreement covering the purchase of thirty (30) LM 2500 shipsets (120 modules) also has an escalation clause. However, the clause is different from that in the GE/BIW option agreement and does not relate to time of delivery of each module. The multiplier in the escalation article is \$129.986 million. Prices of the LM 2500 module under the GE/Litton option agreement are as follows:

Base price 120 modules (including all nonrecurring work)	\$137.3 million
Base price (unescalated) per module	\$ 1.144 million
Return cost 120 modules:	
Base price	\$137.3 million
Escalation	34.285 million
Return cost (escalated) per module	\$1.430 million

The GE/Litton option agreement also had a provision that if only 64 modules were purchased instead of 120 modules, the base price per module would be about $1.28 million.

NAVSEC 6146 bases its LM 2500 cost estimates on experience and cost records. For example, the estimated cost per module of $1.3 million made by NAVSEC in 1970 was based on the $1.28 million per module figure contained in the General Electric/Litton option agreement. In 1971 the estimate per module was raised to $1.5 million.

The Guided Missile Frigate (FFG) Ship Acquisition Project Office (PMS 399) used the following methodology (Table E.84) for developing the LM 2500 budget estimates.

TABLE E.84

FFG LM 2500 COST ESTIMATE METHODOLOGY

Program Year	Estimated Cost Per Ship Set (2 modules) ($ millions)		Estimated Unit Cost (1 module) ($ millions)
FY 1976	5.71	(Estimate from SUPSHIP, Bath)	
BIW Fee	x 1.03		
	5.88		2.94
FY 1977	5.88	(FY 1976 estimate)	
Inflation FY '77T	x 1.028		
Inflation FY '77	x 1.102		
	6.661		3.33
FY 1978	6.661	(FY 1977 estimate)	
Inflation FY '78	x 1.084		
	7.220		3.61
FY 1979	7.220	(FY 1978 estimate)	
Inflation FY '79	x 1.066		
Provision for new negotiations with GE	x 1.2		
	9.236		4.62

Estimates generated by PMS 399 in late July 1977 for FY 1977, 1978, and 1979 programs are slightly lower than the foregoing estimates.

NAVSEA 01G works closely with the SHAPM's (Ship Acquisition Project Managers) in developing the LM 2500 cost estimates that are utilized in preparing new ship construction cost estimates for inclusion in budget estimates submitted to Congress. The development of the estimated cost for one FFG in the budget submittal to Congress for FY 1973 can serve as an example of the NAVSEA 01G methodology. In this ship cost estimate, the LM 2500 module cost was estimated at $3 million per ship set ($1.5 million per module) to which 15 percent was added on the basis of a two shipset buy (the FFG and the Land Based Test Site) instead of a 50 shipset buy. This raised the estimate to $3.450 million per ship set ($1.725 million per module). This NAVSEA 01G estimate tracks into the 211 line item in the final budget submittal to Congress.

None of the cost estimates for LM 2500 modules reflect any part of the Project Managers Reserve of 10 percent for all GFE, including LM 2500's, that is included in new ship construction cost estimates in budget submittals to Congress.

(4) An Historical Track Of Cost Estimates For LM 2500 Modules Is Difficult To Develop By Reason Of Lack Of Records And Inconsistency In Estimate Format

The organizations that develop LM 2500 cost estimates have no data banks of such estimates. Rather, any information needed must be obtained through a search of the files. Also, many cost estimates are not comparable because, depending on the type of ship, configurations of the LM 2500 differ (e.g., the FFG's utilize standard LM 2500 modules, the PHM mounts its LM 2500 directly in the engine room, without the standard base/enclosure assembly).

In order to develop an historical track of LM 2500 cost estimates that would be meaningful, only estimates of LM 2500 marine gas turbine modules were considered, and of these, primary attention was given to those connected with the Guided Missile Frigate (FFG) program. The DD 963 Class destroyer program did not have truly comparable estimates available because the LM 2500 modules were CFE rather than GFE.

An historical track of selected cost estimates for the LM 2500 marine gas turbine module for the calendar year period 1970 - 1977 is shown in Table E.85.

In 1970, estimated cost of an LM 2500 module was $1.3 million; in 1977 estimated cost of an LM 2500 module for use in the FY 1979 Guided Missile Frigate (FFG) program has risen to as high as $4.6 million. This was an apparent cost growth of 256 percent over an eight year period; which equals a compound estimate growth rate of 15 percent.

According to the various organizations making LM 2500 cost estimates, the principal LM 2500 cost drivers in the FFG program include the following:

- Inflation (reflected in escalation as per option agreement for 60 modules)
- Changes in engine
- Smaller ship buy than originally planned
- Expiration of 30 shipset option at end of FY 1978, with consequent necessity of having to provide contingency for added cost for FY 1979 renegotiation.

(5) The Unit Cost Of An LM 2500 Module Rose About $1 Million In Seven Years

The contract unit cost of an LM 2500 module rose about 50 percent in the seven-year period 1970 - 1977. In 1970 the unescalated base price for an LM 2500 marine gas turbine module, as provided for in the General Electric/Litton option agreement for 120

TABLE E.85

LM2500 MARINE GAS TURBINE MODULE: SELECTED COST ESTIMATES 1970 - 1977

Calendar Year	Estimated Unit (Module) Cost for Guided MissileFrigate (FFG) Program	
	Millions of Dollars	Organization providing estimate
1970	1.3	NAVSEC
1971	1.1 (GFE-Government Furnished Equipment)	Do.
	1.2	Do.
	1.5	Do.
1972	1.8	General Electric quote to Bath Iron Works
1973	2.0 (FY '73)	NAVSEA 01G
	1.85 (FY '74)	Do.
	2.13 (FY '74)	Do.
	2.27 (FY '75)	Do.
	1.5	Project Manager, for FFG (PMS 399)
1974	2.78 (FY '75) This figure used in preparing Budget submission to Congress	Project Manager, for FFG (PMS 399 P)
1975	2.15	NAVSEC
	1.96 (for 1 of 30 follow ships)	Project Manager, for FFG (PMS 399)
	2.855	SUPSHIP, Bath
	2.94 (FY '76) This figure used in preparing Budget submission to Congress	Project Manager, for FFG (PMS 399 P)
1976	GFE - Government Furnished Equipment:	
	3.33 (FY '77)	Project Manager, for FFG (PMS 399 P)
	3.61 (FY '78)	Do.
	2.996 (FY '76)	NAVSEA 012
	3.330 (FY '77)	Do.
	3.731 (FY '78)	Do.
	4.620 (FY '79)	Do.
	The NAVSEA 012 figures used in preparing Budget submissions to Congress.	
1977	GFE -Government Furnished Equipment:	
	3.33 (FY '77)	Project Manager, for FFG (PMS 399)
	3.61 (FY '78)	Do.
	4.62 (FY '79)	Do.
	3.330 (FY '77)	NAVSEA 012
	3.615 (FY '78)	Do.
	4.626 (FY '79)	Do.
	The above PMS-399 and NAVSEA 012 figures used in preparing Budget submissions to Congress.	
	3.216 (FY '77)	Project Manager, for FFG (PMS 399)
	3.486 (FY '78)	Do.
	4.464 (FY '79)	Do.
	These PMS-399 figures as of 7/28/77	
	2.285 (est. 1978 delivery)	General Electric Company
	2.34 (est. 1979 delivery)	Do.
	These are GE figures as of 8/3/77	

modules for the SPRUANCE (DD 963) Class destroyer program was about $1.1 million; the final escalation return cost per module under this agreement, with all deliveries made in the 1972 - 1976 period, was $1.43 million. In 1977, the return cost for 12 modules shipped in place, stored at Evendale and owned by Navy, under the terms of the General Electric/Bath Iron Works option agreement for the FY 1976 Guided Missile Frigate (FFG) program was $2.08 million ($2.14 million if 3 percent fee to Bath Iron Works for services as purchasing agent to Navy is included). It should be noted that the LM 2500 modules procured for the DD 963 Class destroyers were CFE, the modules being procured for the follow-on ships of the FFG program are GFE.

Selected contract unit (module) cost for LM 2500 marine gas turbine modules for the period 1970 - 1977 are shown in Table E.86 . The unit costs for the modules purchased as GFE do not include the fees to Bath Iron Works for services as purchasing agent to Navy.

(6) <u>Cost Estimates By Navy For LM 2500 Modules Have Been Consistently Higher Than Actual Costs</u>

Navy estimates of the cost of LM 2500 modules made during the period 1970 - 1977 have been consistently higher than actual return costs. The cost growth as projected by selected estimates and

TABLE E.86

LM2500 MARINE GAS TURBINE MODULE: SELECTED CONTRACT COSTS

1970 - 1977

Calendar Year	Contract Unit (Module) Costs for SPRUANCE (DD-963) Class Destroyer and Guided Missile Frigate (FFG) Programs — Millions of Dollars	Organization Providing Data
	CFE - Contractor Furnished Equipment:	
1970	1.1 (DD-963 program) (120 units) or	Litton
	1.28 (DD-963 program) (64 units) Above prices subject to escalation provision.	Do.
1971	—	--
1972	* 1.43 (DD-963 program)	SUPSHIP Pascagoula
1973	* 1.43 (DD-963 program)	Do.
	1.42 (FFG program) (7/6/73 option 60 modules)	Bath Iron Works/General Electric Company
	1.4 (FFG program) (renegotiated option)	Do.
	1.31 (FFG program) (renegotiated option price less product improvement and warranty)	Do.
	FFG prices subject to escalation and other adjustments depending on time of delivery.	
1974	1.66 (FFG Land Based Test Site) (7/74 billing date)	Bath Iron Works/ General Electric Company
	* 1.43 (DD-963 program)	SUPSHIP Pascagoula
1975	1.72 (FFG Lead Ship) (9/75 billing date)	Bath Iron Works/ General Electric Company
	* 1.43 (DD-963 program)	SUPSHIP Pascagoula
1976	* 1.43 (DD-963 program)	SUPSHIP Pascagoula
	GFE - Government Furnished Equipment:	
	2.01 (FFG FY '75 program) (6 modules shipped in place, stored at Evendale, owned by Navy)	General Electric Company
1977	2.08 (FFG FY '76 program) (12 modules shipped in place, stored at Evendale, owned by Navy)	General Electric Company

* Average price for Five Year Period

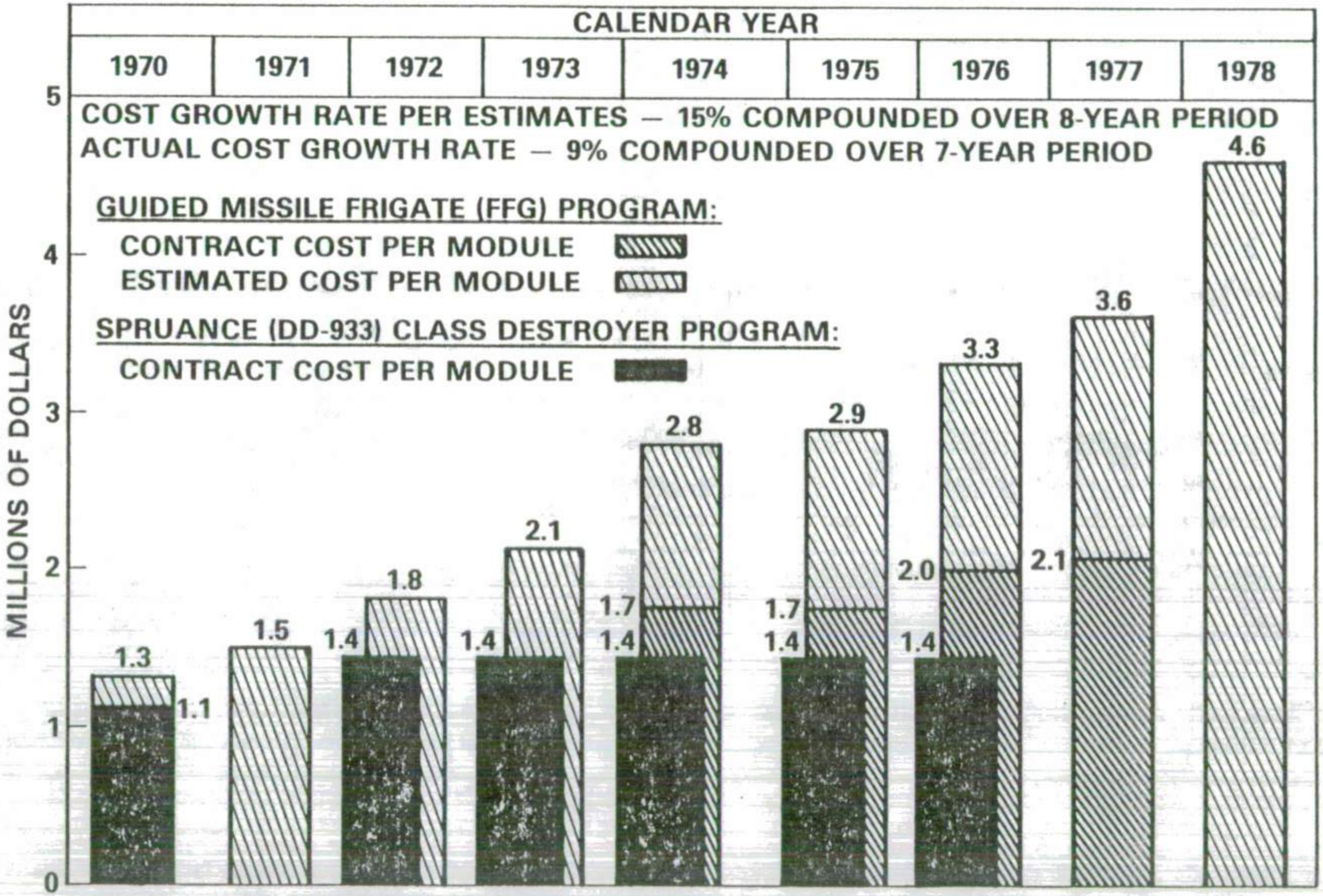
the actual cost growth of the LM 2500 module for the period 1970 - 1979 is shown in Figure E.20.

The cost growth rate according to the Navy estimates covering 1970 to 1979 is 15 percent compounded over the nine-year period. The actual cost growth rate from 1970 to 1977 is 10 percent compounded over the seven-year period. In calendar year 1976, the cost estimate for an LM 2500 module used in preparing the budget submission to Congress covering the FY 1976 Guided Missile Frigate (FFG) program was $2.996 million; in calendar year 1977 the actual cost per module of 12 modules shipped in place, stored at Evendale and owned by Navy for the FY 1976 FFG program was $2.08 million ($2.14 million, including Bath Iron Works 3 percent fee). The estimate, then, was about 40 percent higher than the actual cost. In calendar year 1977, the cost estimate for an LM 2500 module used in preparing the budget submission to Congress covering the FY 1978 FFG program was $3.6 million. This estimate is about 70 percent higher than the actual cost per module of 12 modules shipped (but stored at Evendale) by General Electric in calendar year 1977 for the FFG program.

Estimates made by General Electric on August 3, 1977 project that the unit cost of an LM 2500 marine gas turbine module for the FFG program will be $2.285 million for delivery in calendar year

FIGURE E.20

LM 2500 COST GROWTH 1970 - 1978



SOURCES: BASED ON INFORMATION FROM NAVAL SEA SYSTEMS COMMAND, SUPSHIP PASCAGOULA NAVAL SHIP ENGINEERING CENTER, AND GENERAL ELECTRIC COMPANY

1978 and $2.34 million for 1979 delivery. These figures would be about $2.35 million and $2.41 million, respectively, if the BIW 3 percent fees were included. Estimates made by Navy of the unit cost (including the BIW fee) of an LM 2500 marine gas turbine module for the FY 1979 FFG program have ranged from about $4.62 million, used in preparing a budget to Congress, to $4.464 million in a late July 1977 estimate. The Navy estimates are about $2 million per module higher -- or at least 85 percent higher -- than those of General Electric.

(7) Evaluation Of The Navy LM 2500 Cost Estimating Capability Indicates That It Should Be Improved

Evaluation of the Navy's LM 2500 cost estimating capability and performance, as developed in some detail in the preceding sections, indicates that considerable improvement should be made in the estimating capability and in the quality of the estimates.

*   *   *   *   *

The following is a summation of the cost estimating process for the LM 2500 Marine Gas Turbine:

- Staffing and Organizational Structure -- Estimates made by NAVSEA 01G, SHAPM's, SUPSHIPS, NAVSEC; considering total number of persons involved in all organizations, staffing is adequate.

- Data Banks -- None. Estimates must be obtained from files of the various organizations.

- Return Cost and Bid Data -- Very scarce or nonexistent in the files of the various Navy organizations making estimates.

- Escalation and Inflation Predictions -- Inflation factors are used in developing estimates, but little, if any, use is made of the escalation formula contained in the General Electric/ Bath Iron Works option agreement covering the procurement of 60 LM 2500 modules.

- Quality vs. Available Technical Description -- Very detailed descriptions are available on the LM 2500 marine gas turbine module and its various components. The GE/BIW option agreement for 60 LM 2500 modules is very detailed also. Even so, the estimates have been consistently higher than return costs, with recent estimates being at a minimum 40 percent higher than related return costs. Looking into LM 2500 module deliveries to the FFG program in 1978 and 1979, Navy estimates are over $2 million per module higher -- or at least 85 percent higher -- than General Electric estimates. Also, it is worthy of note that none of the Navy cost estimates for LM 2500 modules reflects any part of the Project Manager's Reserve of 10 percent for all GFE (Government Furnished Equipment), including LM 2500's, that is included in new ship construction cost estimates in budget submittals to Congress.

- Estimating Response Time -- Time taken to develop an estimate depends on when estimate is needed. If an estimate is needed quickly, it is provided quickly. Whether such an estimate is of high quality is conjectural.

- Review Procedures -- NAVSEA 01G and SHAPM's coordinate their estimates, but the methodology used by Navy organizations involved in LM 2500 cost estimating is not standardized.

- Technical Complexity And Value Of A Unit Of The Product -- The LM 2500 marine gas turbine module is of great technical complexity. The actual unit value, or price, for twelve LM 2500 modules delivered to the Navy in 1977 was $2.08 million per module ($2.14 million if BIW 3 percent fee is included). Since the Navy cost estimate for these was at $2.996 million per module, the Navy estimate of the total cost of these particular twelve modules was over $10 million too high.

VII. PERFORMANCE EVALUATION

Over the last eight years, the Navy has requested funding for 132 ships in 13 major classes totalling some \$18.8 billion. In late 1976, the Navy estimated that to maintain this program in a fully funded status, \$22.2 billion would be required -- an 18 percent increase of \$3.4 billion.

TABLE E.87

SHIPBUILDING PROGRAM -- 1970 - 1977

	No Escalation ----Constant 1970 Dollars-----				Escalation -----Then Year Dollars-----			
	Estimate	Actual	Difference	%	Estimate	Actual	Difference	%
SSN 688	4,931	5,198	267	5	6,033	6,382	349	6
TRIDENT	2,519	2,896	377	15	3,320	3,816	496	15
CVN	1,259	1,681	422	33	1,418	1,943	525	37
CGN	833	1,005	172	21	944	1,140	196	21
DD 963	2,334	3,128	794	34	2,739	3,696	957	35
FFG	1,648	1,882	234	14	2,136	2,370	234	11
LHA	573	847	274	48	590	872	282	47
AD	407	503	96	24	579	708	129	22
AS	325	447	122	38	434	577	143	33
AOR	50	75	25	50	57	86	29	51
AO	309	263	(46)	(14)	443	375	(68)	(15)
PHM	71	181	110	154	96	243	147	153
Total	15,259	18,106	2,847	19	18,789	22,208	3,319	18

SSBN conversions not included.

1. THE NAVY'S ABILITY TO ESTIMATE BASIC SHIP CONSTRUCTION COST SHOWS A WIDE RANGE OF VARIANCE

The Navy's overall ability to predict the total ship construction program cost since FY 1970 is shown on Figure E.21 . The Navy's estimate reporting system shows an average cost growth over the original budget of 23 percent for FY 1970 through FY 1975. The records also show a prediction of substantial improvement for FY 1976 and 1977, but these programs are still in their early stages -- their cost may change.

Figure E.22 shows the dollar value of the cost growth in three areas.

- Contract Escalation -- this is the additional amount paid under the contract provision compared to what was originally estimated to be paid.
- Basic Construction -- this shows additional cost of basic ships without GFM from the first budget estimate submitted and approved by Congress to the present. These increases reflect design changes, increases in inflation rates, and changes in productivity assumptions that take place prior to contract award.
- Net Other -- this is primarily increases in the cost of GFM hardware and changes in margins.

We have mentioned that escalation has been a major element of cost growth. It has, therefore, received a great deal of attention in the last few years and by and large, the more recent budget estimates have large allowances for escalation that are now being accepted by the review chain.

FIGURE E.21

PROGRAM COST GROWTH

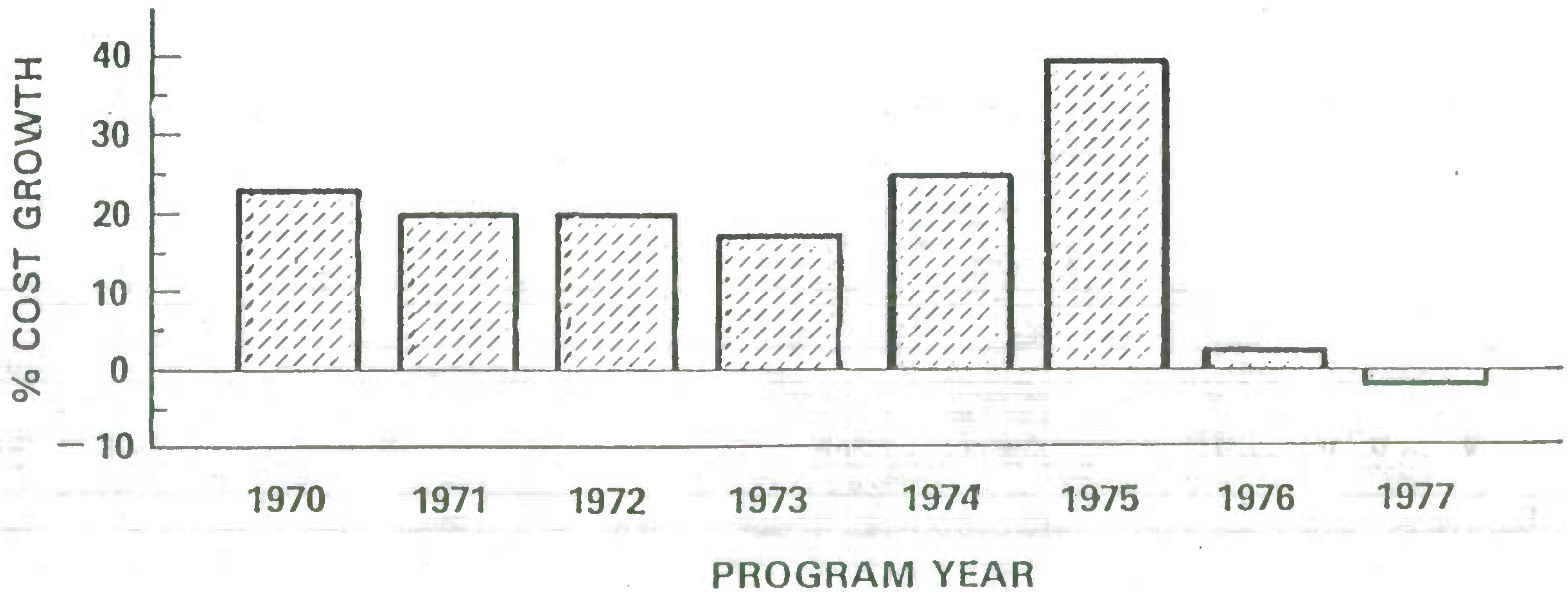
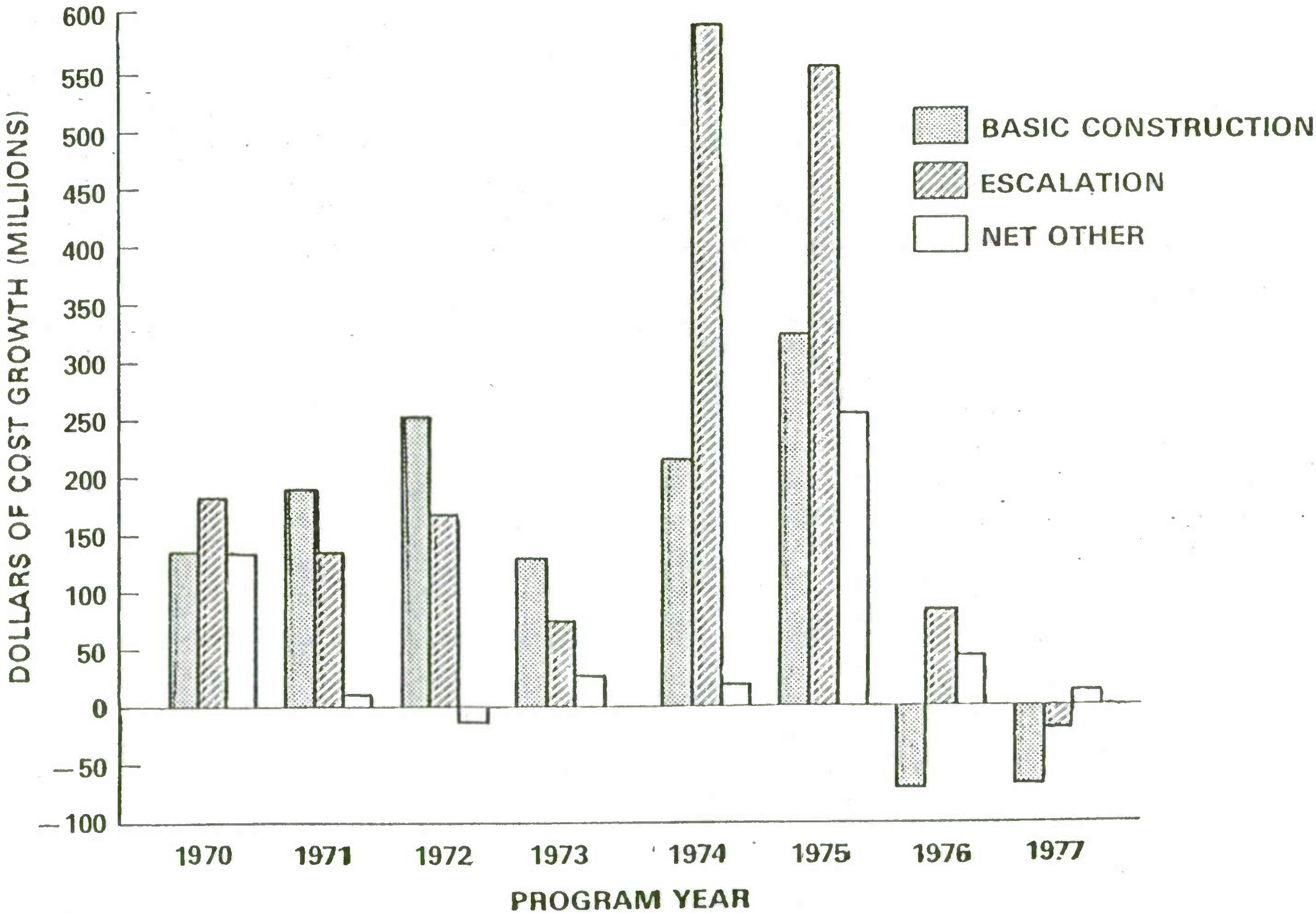


FIGURE E.22

BREAKDOWN OF DOLLAR GROWTH



2. <u>THE SHIP CASES PROVIDE ADDITIONAL DATA BEARING ON COST GROWTH</u>

In Chapter II of this appendix, 39 potential cost drivers were identified. As each ship was studied, the occurrence of these potential cost drivers was noted. Table E.88 shows their occurrence on each ship project. If the cost driver was present, it is so indicated by an X; if the cost driver was a serious problem, it is noted by a 2X.

No percentage or finer weighting can be applied to the table, but it can be suggested that

- The greater the number of these items present, the greater the difficulty for the estimator.
- The number of cost drivers present correlate roughly with the magnitude of the overruns:
  - SSN 678 -- 20 percent growth, 4 drivers
  - FFG 7 -- 41 percent growth, 17 drivers
  - AOR 7 -- 52 percent growth, 18 drivers

Touching briefly on the reason for choosing these particular items as cost drivers, the following is submitted.

- Constraints on estimates
  - Pressure existed in the FFG program to maintain estimates at or below DTC goals.
  - Official directives constrained estimates during AOR 7 budgeting.

TABLE E.88

INFLUENCE OF COST DRIVERS

COST DRIVER	PRESENCE OF COST DRIVERS SSN 678	FFG 7	AOR 7
Programming/Budgeting			
constraints on estimates		X	2X
unanticipated escalation		X	2X
reduced program			
program uncertainties		X	X
additional stack units			
Technical Definition			
insufficient definition		X	2X
system upgraded	2X	2X	
additional systems	X	X	X
additional specifications	2X	X	X
incorrect plans			X
late changes under contract	X	X	X
Estimating			
poor estimates			X
inadequate time to estimate			X
changed market conditions		2X	X
different overhead burden		X	
less efficient shipyard			
low productivity		X	
fewer shipyards			
retention of shipbuilding base		X	
Personnel			
management instability			
too few estimators			
estimating responsibilities diffused			2X
Scheduling			
schedules event delays		X	X
poor scheduling		X	X
late GFE/GFI			X
late CFE/CFI		X	2X
Contracting			
poor form of contract			
Construction			
technical difficulties		X	
shipbuilder's backlog			
low productivity		X	X
work stoppages			X
mismanagement			
inadequate facilities			
labor shortage			
Government Programs			
management layering			
excessive management			
excessive inspections			
social programs			
delay in government actions			
TOTALS	4	17	18

- Unanticipated escalation

  - Important at the very beginning of the FFG program, but estimates soon took high escalation into account.

  - AOR 7 escalation was used up prior to delivery and additional funds requested -- never really had a handle on escalation estimates.

- Program uncertainties

  - Uncertainties about ordnance and sensors, operational testing, cost effectiveness -- all have caused cost growth in the FFG program.

  - Uncertainties relating to characteristics (modified repeat versus new class), acceptable budget cost, completeness of prior ship drawings -- all caused growth in the AOR 7.

- Insufficient definition

  - Certain GFM characteristics were not decided upon until late in development and caused bad end cost estimates. FFG

  - Drawing and specificatons of prior ships in the class were not kept up-to-date. AOR 7

- System upgraded

  - The SSN 678 was the first ship in the SSN 637 class to have the re-engineered hull.

  - New, more capable GFM were added to ship, i.e., FCS, sonar, gun, etc. FFG

- Additional systems

  - In the SSN 678 -- AIGS III S&W, improved PUFFS, Satellite navigation, new launch console.

  - In the FFG -- LAMPS III, CIWS, extra generator, TACTLASS.

  - In the AOR 7 -- helo hangers, NATO SEASPARROW, improved habitability, updated communications.

- Additional specifications
  - On all ships, additional systems and/or modified systems caused additional specifications and costs throughout the building period.
- Incorrect plans
  - As has been mentioned, the AOR 1 through 6 plans had not been kept up-to-date.
- Late changes under contract
  - HMRs were common for all three ships.
  - Plans changes for SSN 678 amounted to $9 million, for the FFG 7 about $20 million and a much smaller figure for the AOR 7.
- Inadequate time to estimate
  - AOR 7 estimates often were made in less than a day.
- Changed market conditions
  - The FFG program office listed nine companies capable of building the ship, only two were interested; effect was to add $8 million to an average follow ship.
  - Stable economic and market conditions existed for the SSN 678, quite the opposite for the AOR 7 and FFG 7.
- Different overhead burden
  - Overhead for the shipyards building the FFGs was greater than estimated due to lack of other repair and commercial work.
- Low productivity
  - Only the FFG 7 can be said to suffer from lowered productivity to a serious extent. This was due to lack of prior complex Navy construction, layoffs for lack of work, etc.

- Retention of shipbuilding base -- funds were spent (but not estimated) to secure larger industry participation. FFG

- Estimating responsibilities diffused -- with the AOR 7, available money seemed to drive the estimate. Arbitrary figures were suggested and the estimate had to conform.

- Schedule delays --

  - The FFG 7 construction delays approach one year.
  - AOR 7 delay was nine months.

- Poor scheduling -- scheduling of CFM procurement was responsible for problems in AOR 7 construction and early design delays caused a similar problem with the FFG 7.

- Late GFE/GFI -- the NATO SEASPARROW was late and was part of the HMR negotiated on the AOR 7. Also, the late information to bring plans up-to-date caused delay and expense.

- Late CFE/CFI -- this became a critical problem on the AOR 7 especially in the valve area; a six month delay in ordering CFM took place on the FFG 7.

- Technical difficulties -- Bath Iron Works has had difficulties in installation of the propulsion system and general problems with complexity of ship outfitting.

- Low productivity -- a generally lower than predicted productivity present in both AOR 7 and FFG building periods. Manhour estimates greatly exceeded.

- Work stoppages

  - Strikes occurred at BIW and Sperry Rand and may have had minor cost effect on FFG 7.

  - Strike at NASSCO may have had minor effect on AOR 7.

3. THE GFM CASE HISTORIES PROVIDE ADDITIONAL INFORMATION REGARDING ESTIMATING AND COST GROWTH

Cost estimating for GFM is, except for several recent cases studied, so called as to not allow the chart approach to cost drivers used with the ship studies. In general, estimates are quotes from vendors with installation mark-ups added, or contract prices escalated forward but seldom is there a concerted effort to maintain control over unit costs of shipboard equipment.

Some general conclusions can be made about many GFM systems:

- There is no uniform method of estimating for GFM.
- No data banks are maintained so that a review of past costs can be performed by Navy management or others.
- From information that can be collected, wide, unexplained variances exist in estimates made for ships. These variances have no consistancy by year or by similar ships.
- Although in many systems solid technical baselines exist, estimating and cost control personnel are not required to take advantage of this situation to improve estimating performance.
- Installation add-ons seem to have no particular relationship, except in a few cases no return costs are required or utilized.
- Sole source procurements have tended to exhibit faster cost growth and estimating difficulty than completion procurements.
- Although weapons and sensors are being estimated for SCN appropriations, many have R&D quality baselines making it difficult, if not impossible to estimate to the weapon or sensor to which they are applied. All GFM gets the same handling.

All these points apply to a number of GFM items -- irrespective of cost. The more expensive items (over $4 million) are handled similarly to cheaper items (less then $1 million).

Some GFM procurements studied stand out as well managed, and cost conscious efforts.

- The procurement of the LM 2500, although estimates are relatively high, shows normal cost patterns, and adequate data would seem to be available.
- The CIWS project exhibits particular cost consiousness and much effort is placed in preparing accurate projections and managing to a cost target.

Recent setps taken by NAVSEA 01G provide some prospect for improvement, but much more should be done to estimate and control the procurement of GFM which amounts (over the last eight years) to $150 million.

EXHIBIT E.1

CLASSIFICATION AND MISSION OF THE PRINCIPAL SHIP CLASSES IN THE FY 1970 - 1977 SCN PROGRAMS

The ships fall into two of the four classifications,[1] i.e., Combatant Ships and Auxiliary Ships. Combatant Craft and Service Craft are not included.

Combatant Ships include the following types:

- Warships

Aircraft Carrier (nuclear propulsion)	CVN
Guided Missile Cruiser (nuclear propulsion)	CGN
Destroyer	DD
Guided Missile Frigate	FFG
Patrol Combatant Missile (hydrofoil)	PHM
Submarine (nuclear propulsion)	SSN
Fleet Ballistic Missile Submarine (nuclear propulsion)	SSBN

- Amphibious Warfare Ships

Amphibious Assault Ship (general purpose)	LHA

The Auxiliary Ships include:

. Destroyer Tender	AD
. Replenishment Oiler	AOR
. Submarine Tender	AS
. Fleet Oiler	AO

[1]Taken from "Classifications of U.S. Naval Ships and Craft" dated Jan. 6, 1975.

A brief description and statement of the mission of these ship types will highlight the differences in design in terms of size, configuration and type of armament.

CVN - an all purpose nuclear propelled aircraft carrier with an overall length of 1092' and maximum flight deck width of 252'. The waterline length and beam are 1040' and 134', respectively. The estimated total ship manning is 5,722. Its mission is to operate aircraft and engage in attacks on targets at sea and ashore. At sea, targets include those submerged as well as those afloat.

CGN (38 class) - a nuclear powered guided missile cruiser with an overall length of 585' and maximum beam of 63' with accommodations for 497 personnel. The ship is armed with missiles for both antiair and antisubmarine warfare. Additional armament includes guns, torpedoes, electronic warfare suite and provision for an embarked helicopter. It operates offensively, independently or with strike, antisubmarine or amphibious forces against air, surface and submarine threats.

DD (963 class) - a gas turbine driven destroyer measuring 563' overall and maximum beam of 55', with accommodations for 296 personnel. Its primary missions are to: 1) provide protection to Attack Carrier Forces against surface/submarine threat, 2) escort Amphibious Assault/Preassault forces, and 3) conduct shore bombardment in support of amphibious assault on land warfare forces. This ship also has numerous secondary missions, one of which is limited air control. Armament required to carry out its three types of warfare are included, i.e., torpedoes, guns and missiles.

FFG - a gas turbine powered guided missile frigate with an overall length of 445', maximum beam of 45' and accommodations for 185 personnel. Its mission is to provide self-defense and supplement escorts in the protection of underway replenishment groups, amphibious forces and mercantile shipping against sub-surface, air and surface threats. Armament includes missiles, torpedoes, a rapid fire gun and hangar facilities for two helicopters.

PHM - a patrol combatant missile (hydrofoil) measuring approximately 132' in overall length with foils down and a 28' beam at main deck level. Accommodations are provided for 21 personnel. Its mission is to operate offensively against major surface combatants and other surface craft, and to conduct surveillance, screening and special operations. Propulsion is by waterjet

pump; foilborne driven by a gas turbine engine and hullborne by two diesel engines. Armament includes surface to surface missiles and gun with appropriate fire control system.

SSN (688 class) - a high-speed nuclear attack submarine with an overall length of 360' and 33' maximum beam and accommodations for a crew of 102. Its mission is to destroy enemy shipping including sumarines and surface ships. It is armed with torpedoes and missiles, advanced sonar and fire control systems and a central computer complex to integrate navigational and fire control data processing.

SSBN (Trident) - a fleet ballistic missile submarine measuring approximately 560' in length and 42' in diameter with accommodations for a crew of 150 personnel. It is equipped with long-range strategic ballistic missiles and facilities necessary to support the submarine and strategic weapon system. The Trident submarine offers the best of current technology.

LHA - a general purpose amphibious assualt ship measuring 820' in length overall and 106' beam with accommodations for a total of 2,805 personnel, which includes a crew of 762. Its mission is to transport and put ashore troops and their essential combat equipment and supplies by means of embarked helicopters, amphibious craft and amphibian vehicles. It is equipped with 3 5" lightweight guns, Basic Point Defense Surface Missile System and fire control.

AD (41 class) - a destroyer tender measuring 643' in length overall and 85' maximum beam with a total of 1,508 accommodations. Its mission is to provide necessary material and shops for the calibration, test and overhaul of equipment and the accomplishment of repairs not requiring shipyard facilities for all destroyer/frigate types including CGN nuclear propulsion support. Armament includes Sea Sparrow missiles and appropriate fire control.

AS (39 class) - a submarine tender measuring 643' in length overall and 85' maximum beam with accommodations for 1,351 personnel. Its mission is to provide mobile base facilities capable of furnishing maintenance and logistic support for nuclear attack submarines, including SSN (688 class), operating from advanced sites. Armament includes Sea Sparrow missiles and appropriate fire control.

AOR-7 (1 class) - a replenishment oiler of approximately 658' in length overall and 96' beam with accommodations for 457 personnel, built to commercial standards. Its mission is to provide rapid replenishment of petroleum products, ammunition, provisions, repair parts, consumable stores and fleet freight to operating forces, by underway replenishment and helicopter operations. Armement includes Sea Sparrow missiles and appropriate fire control.

AO (177 class) - a fleet oiler measuring 592' in length overall and 88' beam with accommodation for 135 personnel. Its mission is to furnish petroleum products to operating forces at sea. Armament includes 2 close-in PHALANX weapon system (CIWS).

EXHIBIT E.2

SHIPYARDS CONSTRUCTING THE PRINCIPAL SHIP CLASSES IN THE FY 1970 - 1977 SCN PROGRAM

The number of shipyards involved in the program is indicated in the table below. The FFG and SSN programs are contracted to more than one yard. Each of the other ship types in the FY 1970 - 1977 programs included herein, and awarded to date, is concentrated in one shipyard. The breakdown, by ship type, is as follows:

Ship Type	Newport News	Electric Boat	Ingalls (Litton)	Bath	Todd, San Pedro	Todd, Seattle	National Steel	Lock-heed	Avon-dale
SSN	10	18							
DD			30						
FFG				6	3	1			
TRIDENT		4							
LHA			4						
CGN	4								
AD							2		
AS								2	
CVN	2								
AOR							1		
PHM (1)									
AO									2

NOTE: (1) Four PHMs authorized in FY 1975 out of SCN funds have not been contracted. Two PHMs authorized in FY 1973 are under contract with Boeing Company, Seattle, Washington but, since they are funded out of RDT & SE, the are not included herein.

In testimony before the U.S. Senate Committee on Armed Services on April 29, 1976, the Honorable William P. Clements, Jr., Deputy Secretary of

Defense, testified regarding the decreasing number of shipyards engaged in naval ship construction, as follows:

> "In 1960, 14 private shipyards were engaged in the construction of 83 major combatant, amphibious warfare, and large auxiliary naval vessels. Also, naval vessels were built in five naval shipyards. Fifteen years later, in 1975, over 90 percent of the Navy's shipbuilding program (62 out of 66 ships) was concentrated in three yards (Newport News, Electric Boat, and Ingalls* and no new construction ship project has been assigned to a naval shipyard since 1967."

The situation has begun to change in that more shipyards are involved in the construction of naval ships. Currently, 9 shipyards have contracted for the construction of 90 major combatant, amphibious warfare and large auxiliary ships. Of the 90 ships that have been contracted with these yards, 72, or 80 percent, are with the same three shipyards: Newport News, Electric Boat and Ingalls. The trend toward a more equitable distribution appears to be in the making considering the current estimate of a 74 ship FFG program and the involvement of 3 shipyards in the construction of this type at the present time.

Only two yards, Electric Boat and Newport News, are now involved in construction of nuclear propelled ships. Electric Boat has engaged in construction of submarines only and is, thus far, the only yard to be awarded contracts for construction of the Trident Class submarine. Newport News, on the other hand, has contracted to build surface as well as subsurface nuclear ships and is, at present, the sole source for CVNs and CGNs.

Ingalls* has been the major producer of non-nuclear combatant ships, being the sole source for LHAs and DDs. Newport News and National Steel are the only other yards producing more than one type of ship.

* Ingalls Shipbuilding Division, Litton System Inc., Pascagoula, Mississippi.

EXHIBIT E.3

ACQUISITION STATUS OF THE PRINCIPAL SHIP CLASSES IN THE FY 1970-1977 SCN PROGRAMS

The SSN (688 class) program was initially authorized in FY 1970 with appropriations for three ships and has continued through FY 1977 for a total of 31. The total estimated number of ships in the program is 39, which includes two ships per year in the period FY 1978 through FY 1981. The first, and only ship to be delivered to date, was by Newport News on November 2, 1976. The second is estimated to be delivered by Electric Boat on March 26, 1977. Contracts have been executed for 28 of the 31 ships, with 17 of them in various stages of construction in the two shipyards.

The SSBN (Trident) program commenced with authorization of a single ship in FY 1974. Through FY 1977, five out of a total program estimate of 11 ships have been authorized. Four have been contracted to Electric Boat. Construction has started three of the four and the keel of the first one was laid in April 1976. There have been no deliveries.

The CGN (38 class) commenced with authorization for one in FY 1970 and followed with one each in FYs 1971, 1972 and 1975. All four have been contracted to Newport News. The first ship was delivered in August 1976 and the second is scheduled for mid 1977.

The CVN 69 and 70 were authorized in 1970 and 1974, respectively. Both are of the NIMITZ class. The CVN 68 was delivered by Newport News, where the CVN 69 and 70 are under construction. The shipbuilder's target date for delivery of the CVN 69 is June 1977; however, there is potential for slippage in the date. The CVN 70 is in a much earlier stage of construction.

The DD (963 class) commenced with award of three to Ingalls that were authorized by Congress in the FY 1970 program. A total of 30 ships have been authorized through FY 1975, all of which have been contracted to Ingalls. Five of the ships have been delivered and 21 others are in various stages of construction.

The LHA program began with the award of one ship in the FY 1969 program to the new Litton Ingalls yard. This was followed by the award of two each in Fiscal Years 1970 and 1971. Originally, the program was to be for nine ships, but was reduced to five. The first ship was delivered in May 1976 and the other four are in various stages of construction. Estimated delivery of the second ship is September 1977.

The FFG program commenced with the authorization of the FFG 7 (originally designated as PF) in the FY 1973 program. Through FY 1977, 18 out of a total program estimate of 74 have been authorized, and 10 have been placed under contract. The first ship, being constructed at Bath, was launched

in September 1976 and is estimated to be ready for delivery in December 1977. Construction is not scheduled to start on any of the other ships before March 1977.

The PHM program commenced with the authorization of 2 in FY 1973; however, since these are being constructed (by Boeing Company, Seattle, Washington) with RDT & E funds, they were not included in this review. The first SCN funded authorization was for four in the FY 1975 program. Contract(s) for construction of the latter had not been executed at the time of this review.

The AD (41 class) destroyer tender program was initiated with authorization of one in FY 1975 and continued with one in each of Fiscal Years 1976 and 1977. Contracts have been awarded for two of the three ships and construction of the first of these was scheduled to begin late in 1976. A total program of five ships is estimated.

The AOR 7 was a single ship program which was authorized in FY 1972 and constructed by National Steel and Shipbuilding Company. It was delivered on October 14, 1976.

The AS (39 class) submarine tender program is comprised of three ships which were authorized on a one per year basis in Fiscal Years 1972, 1973, and 1977. The first two ships were placed under contract in

November 1974 with Lockheed Shipbuilding and Construction Company. The keels have been laid for both ships and launching of the first was scheduled for March 1977.

The AO (177 class) fleet oiler, estimated to be an 11 ship program, commenced with authorization of two in FY 1976 and one in FY 1977. The first two ships were placed under contract in August 1976 with Avondale Shipyards Inc. Construction is scheduled to start in December 1977.

EXHIBIT E.4

CLAIMS SITUATION WITH RESPECT TO THE PRINCIPAL SHIP CLASSES IN THE FY 1970 - 1977 SCN PROGRAM

On April 29, 1976, during hearings conducted by the Committee on Armed Services of the United States Senate, the Honorable William P. Clements, Jr., Deputy Secretary of Defense testified as follows:

> "It can be said that the overall universe of the shipbuilding claims problem since January 1969 to April 1, 1976 amounts to $3,189 million. Of this amount, $1,317 million have been settled and $1,872 million are pending."

The settlements referred to in the above statement were on 54 claims submitted by 12 shipyards. The list of claimants included virtually every major shipbuilder in the United States and the types of ships included surface and subsurface combatants as well as a variety of auxiliary ships.

As of December 16, 1976, there were 10 shipbuilding claims by 4 shipyards which totaled $2,141 million. These claims included the following ships in the FY 1970 - 1977 programs:

Yard and Ships		Claim Amount ($ millions)
Newport News		
SSN 688		78.5
SSN 689,691,693,695		191.6
CGN 38-40		159.8
CVN 68,69[1]		221.3
	Sub Total	651.2
Ingalls (Litton)		
LHA 1-5[1]		701.7
Electric Boat (General Dynamics)		
SSN 690,694,696-699		121.3
SSN 700-710		422.6
	Sub Total	543.9
	Total	1,896.8

NOTE: [1]CVN 68 and LHA 1 were authorized prior to FY 1970.

A claim from National Steel & Shipbuilding Company regarding the AOR 7 contract was settled with a Headquarters Modification Request (HMR).

In addition, in hearings before a Subcommittee of the Committee on Appropriations of the House of Representatives on July 20, 1976, Admiral Frederick H. Michaelis, USN, Chief of Naval Material provided a list of probable claims which included the DD 963 program at Ingalls.

EXHIBIT E. 5

STURGEON 637 CLASS SSN CHARACTERISTICS

CHRONOLOGY

FY 62 - (637-639) Original (SCB 188) ship of the SSN 593 class. OPNAV 09010.119A Serial 01328P43 of 6 May 1958 - Change 1-12

FY 62 - 63 - OPNAV 09010.180 Change 1 Serial 01006P42 of 18 October 62.

A. Change 1 to FY 64 characteristics (SCB 188A) below.

1. Extended FY 64 characteristics to FY 62 - 63 (11 ships - 3 - FY 62 - 8 - FY 63)
2. Minor electronic changes
3. Item specified for FY 64 characteristics Schedule "A".

B. OPNAV 09010.180A Serial 01095P36 of 29 May 1963 - redesignated SSN 593 class.

1. Promulgated revised characteristic (188A) for FY 62-63
2. Cancelled OPNAV 09010.180 of 2 July 62
3. Updated electronics - Required SUPRAD and floating wire antenna
4. New self noise goals
5. Surveillance was added as design task
6. Improved near surface depth control
7. Increased in torpedo storage

FY 62 - 63 (Continued)

8. Increase in accommodations

C. Change 1 - OPNAV 09010.180A Change 1 Serial 0456P36 of 28 April 64.

1. Surface performance characteristics specified

2. Added electronic equipment list to accommodate system requirement. - No major chonge

3. Added weapons equipment list

D. Change 2 - OPNAV 09010.180A Change 2, Serial 016P36 of 13 Januory 65.

1. SUPRAD E for two ships in FY 62

2. SUPRAD D for remainder

3. Revised electronics - sonor

E. Change 3 - OPNAV 09010-180A Chonge 3, Serial 01098P36 of 29 November 65.

1. Deleted SUPRAD D for FY 62-63 (all ships) and substituted SUPRAD E.

F. Change 4 - OPNAV 09010.180A Change 4 Serial 0771P36 of 26 November 68.

1. Clarified hovering depth management.

2. Combined Radio/ECM Room for SSN 646 only.

3. Deleted specified equipment.

SSN 647 and 652 provide cable and foundation for Navigotion Satellite Recever.

FY 64

A. FY 64 (A) OPNAV 09010.180 Serial 0623P42 of 2 July 62, (SCB 188A) - Redesigned SSN 593 class. Major change - Sonar.

1. Improved surveillance

2. Improved depth control

3. Increase in torpedo storage

4. Increase in accommodations

B. Above characteristics cancelled by OPNAV 09010.180A of 29 November 1963. New characteristics for FY 64 issued.

C. Next (five ships) revised characteristics for FY 64 ships issued by OPNAV 09010.209 Serial 01096P36 of 24 November 63. Redesignated 593 class FY 62-63.

1. Improved surveillance

2. Improved depth control

3. Increase in weapons storage

4. Increase in accommodations

5. Issued updated electronic suite

6. New self noise goals

D. Change 1 - OPNAV 09012.2-9 Change 1 Serial 085P36 of 31 January 64.

1. Editorial

FY 64 Continued

E. Change 2 - OPNAV 09010.209 Change 2 Serial 0459P36 of 28 April 64.

1. Provided major electronic equipment list. SUPRAD D.

2. Provided major weapon equipment list.

F. Change 3 - OPNAV 09010.209 Change 3 Serial 019P36 of 13 January 65. Same as Change 2 for FY 62-63.

1. Revised electronic suite

G. Change 4 - OPNAV 09010.209 Change 4 Serial 01097P36 of 29 November 65.

1. Deleted SUPRAD D and substituted SUPRAD E.

H. Change 5 - OPNAV 09010.209 Change 5 Serial 0783P36 of 3 December 68.

1. Clarified hovering depth requirement

2. Install fittings for additional equipment

3. Provide combined Radio/ECM Room (SSN 660, 662, 664)

4. Fire control update

5. Weapon capability update - all except SSN 661

FY 65

A. OPNAV 09010.210 Serial 01098P36 of 29 November 63 - SCB 200.65 Basic characteristics - (Continuation of 62/63/64)

1. Updated electronic suite including improved sonar

2. Provide space for BQS-13

B. Change 1 - OPNAV 09010.210 Change 1 Serial 0458P36 of 28 April 64.

1. Issued major electronic equipment list

2. Sonar changes

3. Modified weapons equipment list

C. Change 2 - OPNAV 09010.210 Change 2 Serial 048P36 of 23 January 69.

1. Clarified hovering depth

2. Fittings for underwater tactical range pinger

3. DSRV mating for SSN 667 and 670

4. Combined Radio/ECM Room

5. Deleted Data Correction Computer BQA-4

6. Provide cable and foundation for Navigation Satillite Receiver

7. Provide for MK 113 Mod 6 Vice MK 113 Mod 2

8. Weapon update

FY 66

A. OPNAV 09010.244 Serial 0226P36 of 19 March 1965 continuation FY 62/63/64/65 (SCB 300.66)

1. Fire control MK 113 Mod 2
2. Reserve space for weapon update
3. Revised noise goals

B. Change 1 - OPNAV 09010.244 Change 1 Serial 0229!36 of 18 February 66.

1. Provide for space and weight only for PUFFS

C. Change 2 - OPNAV 09010.244 Change 2 Serial 0366P36 of 30 April 69.

1. Clarified hovering depth
2. Fittings for sonar update
3. DSRV mating capability
4. Radio and ECM Room combined
5. Navigation Satellite Receiver
6. Special ECM antenna
7. Deleted MK 9 Mod 0 and substitute MK 8 Mod 8.
8. Delteted space requirement for EX-13

FY 67

A. OPNAV 09010.272 Serial 082P36 of 1 February 67 Continuation FY 62/63/64/65/66 maximum extent possible SCB 300.67.

1. Lengthen ship 8' - 3"

2. Space and wight reservation for:

   - Acoustic Information Gathering System (AIGS III)

   - Improved PUFFS array and equipment

   - Satellite Navigation System AN/SRN-9

3. Increase accommodations - (3 enlisted)

4. DSRV

5. Change in periscope

6. Rearrange ECM space

7. Electronic suite updated

   Stowage for expendable bathythermograph

   Improved VHF/UHF/IFF System

8. New Weapons Launch Console and Switchboard

9. Revised noise goals

B. Change 1 OPNAV 09010.272 Change 1 Serial 0273P36 of 19 April 67.

1. Deleted Close Contact Tracking System (REVEL) (5 ships)

FY 68

A. OPNAV ltr. 366 Serial 0334P36 of 25 May 67.

Extended FY 67 characteristics to FY 68 ships (2 ships)

Note - Multi-Year buy

FY 69

A. OPNAV ltr. 36C Serial 066P36 of 23 February 68.

Extended FY 67 characteristics to FY 69 ship (2 ships)

B. OPNAV Ltr. OP-366 Serial 0623P36 of 17 October 68 modified FY 67 Characteristics for FY 69 ships to specify MK 113 Mod 10 Fire Control vice MK 113 Mod 8 including CO Display panel.